A Project to design a sustainable vineyard in the UK:
A critical analysis of the viticulture in the UK

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Abstract:

The objective of this thesis is to study the sustainability of viticulture in the United Kingdom. Viticulture in the United Kingdom as a commercially viable proposition is a relatively recent development brought about by climate change. The conclusion of this study is that the biggest threat to the sustainability of viticulture in the United Kingdom is the same climate change that has made it possible. Possible solutions to reduce the environmental impact of viticulture in the United Kingdom are proposed and evaluated.

Resumo:

O objetivo desta tese é estudar a sustentabilidade da viticultura no Reino Unido. A viticultura no Reino Unido, como uma proposta comercialmente viável, é um desenvolvimento relativamente recente causado pelas mudanças climáticas. A conclusão deste estudo é que a maior ameaça à sustentabilidade da viticultura no Reino Unido é a mesma mudança climática que tornou possível. Soluções possíveis para reduzir o impacto ambiental da viticultura no Reino Unido são propostas e avaliadas.

Keywords:
UK viticulture, sustainability, Biodiversity, Vineyard Design

Palavras-chave:

Viticultura no Reino Unido, Sustentabilidade, Biodiversidade, Design de Vinhedos

Resumo Alongado:

O artigo trata-se de propor um projeto para uma vinha sustentável no Reino Unido. A vinha foi projetada com atenção à sustentabilidade econômica, social e ambiental, sendo priorizada a sustentabilidade ambiental. Dados publicados apontaram pelo facto que as práticas agrícolas modernas contribuem para 55% das emissões globais de gases de efeito estufa, e a viticultura como umas actividades agicolas mais praticadas no mundo contribui uma parte importante.

Um exemplo é o uso de tratores para, o artigo compara a sustentabilidade do uso dos tratores e cavalos. As fontes de energia para trator são 9% renováveis e comparação de 60% para o cavalo. A retornar ao cavalo teria um custo econômico, mas, como parte de out-

ras práticas orgânicas, pode aumentar a produtividade e a qualidade das uvas. Outra prática sustentável chave a considerar é a noção de “agroecologia”, em que a vinha é incentivada a prestar atenção especial ao aumento da biodiversidade. Essa biodiversidade pode proteger as videiras de pragas e doenças, incentivando insetos e aves predadores a se reproduzirem e viverem em sebes. Além disso, se o vinhedo não precisar mais pulverizar fungicida para prevenir o oídio, os fungos simbióticos podem crescer no sistema radicular das videiras, aumentando a produtividade e a longevidade das videiras.

Práticas sustentáveis são mais caras e exigem mais investimento. Para mitigar os custos, e possível aderir a uma cooperativa agrícola para reduzir o ônus dos custos das forças de trabalho, grandes máquinas, entre outras coisas, e dar acesso uma adega para a produção do vinho. Além de outras medidas, exploramos a possibilidade de fundar uma denominação inglesa de vinho em Kent e usamos a direcção para aplicar incentivos econômicos que garantem que todas as vinhas usem práticas sustentáveis para garantir a longevidade da região. Há precedentes para esse tipo de denominação em Champagne e no vale do Douro, que pode ser usado como modelo para o Reino Unido.

O Reino Unido produz a maior porcentagem de uvas orgânicas da Europa, mas a produção de vinho orgânico apenas por questões de sustentabilidade é questionável. É mais important-ante trabalhar dentro das restrições da terra e entender os riscos potenciais de doenças e a seleção de cultivares resistentes a doenças. Esse tipo de projeto pode minimizar a necessidade de aplicações de pulverização ou intervenção mecânica.

A vinha proposta e projetada dentro de um lote de 22 hectares no centro de Kent, sudeste da Inglaterra, com aproximadamente 13 hectares plantados com videiras. A vinha custaria 1 094 000 € (£ 933.000) e obteria um retorno total do investimento em dez anos. Presume-se que esta vinha faça parte de uma cooperativa e venda de uvas à taxa média do mercado para vinhos vulgares e premium. A vinha também deixou espaço para incluir fontes secundárias de renda

Em resumo, o artigo conclui que uma vinha sustentavel no Reino Unido é uma proposta comercialmente viável, mas exigiria cooperação em toda a região e legislação governamental antes de se tornar comum. A necessidade de mudança na agricultura é grande e esse pode ser um bom primeiro passo para a viticultura liderar o caminho.

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1. Introduction

1.1 Viticulture in the UK today

The United Kingdom has been producing commercially for roughly the last 20 years, but until recently the climate was too cold and wet to produce anything of note. Recently, thanks to advances in the understanding of viticulture, and more importantly a change in climate around the UK, it has become possible to produce wine of a calibre able to compete on the global market (Schultz and Jones, 2010). Formerly, temperate climate regions like champagne are struggling against increased temperatures of 2°C and extreme weather events (EASAC, 2018). Though the advent of Climate Change has brought the gift of viticulture to the cooler climates (Ashenfelter and Storchmann, 2010), it is also a serious threat to global environments, economies and societies; global warming is projected to be the largest existential threat to life on earth since the meteor which wiped out the dinosaurs (Milman, 2018).

Vineyards are becoming increasingly popular in the south-eastern regions of the UK; Kent, Sussex and Hampshire, have been growing Chardonnay, Pinot Noir, Pinot Meunier and Bacchus with great success and acclaim (Stimpfig, 2018). This could be because they yield more money per hectare than arable or animal farming (Savills World Research, 2017; Jenster and Jenster, 1993). In December 2015 Champagne Taittinger announced that it was expanding its sparkling wine production to Kent (Smithers, 2017). In 2018 England experienced its first bumper harvest with many producers purporting “perfect conditions” for grape production (Moore, 2018).

In 2015 17.7% of the UK’s grape production was from organic vineyards, the largest share in Europe (FiBL, 2017). Although the market has grown, the expansion of organic production has not matched this growth (Mullen, T., 2019), particularly given the fact that the average UK consumer is willing to pay an extra third on the price for an organic wine (Jenster, P. and Jenster, L., 1993). Viticulture represents a small sector of agriculture in the UK, but with the largest proportion of organic production in Europe the rapid growth of this new sector makes it well placed to change the UK’s model of agriculture, if it so chooses.

1.2 Agriculture and viticulture's effect on climate change

Since the Green Revolution of the US in 1950, agriculture in the western world has been heading to a more unsustainable model of mechanised and homogenous agriculture to feed a growing human population (Magil, 2014; Church, 2005; Pimentel, 1996).

This has brought with it many problems such as: an over reliance on fossil fuels and oil derived products (as fuels and sources of nitrates) on farms (Cordell et al., 2009); a rise in health risks posed to workers and rural populations due to an increased usage of hazardous chemicals (Fitzmaurice et al., 2014; Dennis et al., 2010); and, the decrease in global biodiversity, leading to the near extinction of key plant species (Svalbard Global Seed Vault, 2019).

This model of agriculture has spread to viticulture with monocultural fields, the usage of large over the row tractors for hedging, spraying and harvesting. Additionally there is a reliance on irrigation for water and disregard for the pollution or drainage of local water systems (Mateo-Sagasta et al., 2017). Thought this is more a concern in developing countries, many rivers in the UK are at risk of eutrophication from nitrogen fertilisers, which poses a greater risk to the UK ecology (Charlton, 2016).

In addition to this, though the the Green Revolution was a global phenomenon, the UK is among the most impacted by the movement. According to the State of Nature report of 2016, of the 8000 species assessed within the report, 15% are either endangered or extinct within Great Britain. This, among other findings concerning biodiversity and population trends, leads the report to state that the UK is among the most nature-depleted countries in the world (Hayhow DB., et al., 2016). According to a global meta-analysis of changing ecosystems and biodiversity loss, a reduction of an ecosystem’s biodiversity can have devastating effects on the production of plants, equivalent to ozone thinning and nutrient pollution (Hooper et al., 2012).

1.3 Aims of the project

In this report I will attempt to propose a sustainable model for a vineyard from acquisition to the first year of production.

The paper attempts to tackle the biggest problems associated with each pillar of sustainability. Climate change is the biggest threat to the environment, with rising CO_2 levels having a demonstrable causal link in the rise of global average temperatures over the last 50 years

(IPCC, 2018). A large part of climate change is caused by the production of greenhouse gasses, but one of the lesser known causes is the rapid decline in biodiversity caused by monoculture agriculture (Chapin III et al., 2000). The environment of today's agriculture is not the same as it once was in the Green Revolution of the 1950's, (or even twenty years ago) if climate change is not slowed to 1.5°C of warming per annum, this will have unquantifiable and catastrophic consequences for economies around the globe, especially for agriculture (Dietz et al., 2018). The advent of the Green Revolution and mechanisation can also be linked with the degradation of rural communities across the globe (Allanson and Whitby, 2014), thus the question of maintaining social sustainability must also address declining rural populations and income.

In this paper environmental sustainability is given the upmost priority, since both economic and social sustainability is dependant on the environmental well being of our world. In addition to this, the paper recognises that the UK is a capitalist society, therefore by definition each enterprise must be socially and economically sustainable. So whilst we prioritise environmental impact, the economic cost and human cost is always considered as part of being sustainable.

1.4 Definition of key terms

For the purposes of this report I define sustainability as fulfilling the three pillars of environmental, economic, and social sustainability. Which in turn are defined as:

- **Environmental Sustainability** - means the rates of renewable resource harvest, pollution creation, and non-renewable resource depletion that can be continued indefinitely. If they cannot be continued indefinitely then they are not sustainable (Thwink.org, 2019).
- **Economic Sustainability** - means the ability to support a defined level of economic production indefinitely (Thwink.org, 2019).
- **Social Sustainability** - means the ability of a social system, such as a country, to function at a defined level of social wellbeing indefinitely (Thwink.org, 2019).

2. Literature Review

2.1 Evaluation of sustainability of current strategies

2.1.1 Considering traction sources in the vineyard

Tractors are one of the biggest problems brought about by the Green Revolution of the 1950's. A study of emergy analysis of horse and tractor traction attempted to demonstrate the impact tractor usage had on the economy of Sweden via emergy requirements and recuperation of emergy (Rydberg and Jansén, 2002). Emergy is defined as "the amount of energy that was consumed in direct and indirect transformations to make a product or service" (Odum, 1996). In the case of the study the "product" analysed was the traction needed to tow agricultural equipment to make oats, but it also considered the bi-products created by both tractors and horses as part of the analysis.

2.1.1.1 Environmental sustainability

The analysis showed that the sources of energy input for a horse were 60% renewable, while the energy input for a tractor at the moment is only 9% renewable, and this is from indirect sources such as the driver operating the vehicle and the mechanic required to fix it. In addition to this it is worth noting that the energy inputs for a horse can be locally sourced almost anywhere in the world, while the fuel required for tractors, along with the working components of the tractor itself are often imported from specific countries, which is a drain on the local economy surrounding the farm or vineyard.

Another consideration is the by-products of the two. Engel calculated that a draft horse will produce 93,000 kg of CO_2e across its entire 20 year lifespan, including indirect sources such as food and transport costs (Engel et. al, 2011). This gives it roughly an average emission of 4,650 kg of CO_2e per annum serving a farm of approximately 8.4 ha (Rydberg and Jansén, 2002). A vineyard tractor, servicing a plot of approximately 5 ha will use just under 2,000l of diesel per annum (Handler and Nadlinger, 2019), and a combustion engine typically converts 1l of diesel into 2.6301 Kg of CO_2e (Fleet News, 2019). We can estimate that for a 5 ha field a tractor will directly produce 5,000 Kg CO_2e per annum from fuel combustion alone, which is more than the total annual emission from the horse.

2.1.1.2 Economic sustainability

While tractors are designed specifically to provide traction as their primary function. It is important to note that they also supply a source of: rotary energy, which can be transferred to dragged implements. However tractors also provide a source of combustion emissions and scrap metal as by-products, which are considered pollutants. The horse, by contrast, provides traction as well as leather, meat, and manure across it's lifetime. Furthermore horses are able to learn, and can adapt to the work required of them, helping the horse to gradually more efficient at its role (Rydberg and Jansén, 2002).

Tractors could feasibly service 100 ha a year, and they can use a vast and complex arrays of machinery which is unavailable to the horse. A return to horse usage would make the jobs of vineyard operatives more demanding and labor intensive, thus in order to compensate fairly for this an increase in wages is necessary, alongside a larger workforce to even out the labour demand. On a surface level this will increase the cost going into the production of grapes.

The usage of draft horses in viticulture is increasing (Cressent and Jez, 2013), particularly in the region of Languedoc-Roussillon, France. Muller estimates that the usage of horses in the vineyard increases the price of unpackaged wine by 1€/L, but can also increase productivity of the vines by up to 60 L/Ha (Mulier, C. and Müller, H., 2019). Though this is impressive, the source notes that this is part of a larger scheme of organic practices and cannot be attributed to the horse alone.

2.1.1.3 Social sustainability

Due to the low traction output of horses, donkeys, or oxen, the viticulturist will return to manual labor for each individual job. This is costly and not economically sustainable for large scale projects (vineyards of 10 ha or more), which will require a tractor to service the intense labor demand. Horses require the employment of more operatives, and they can work only much smaller plots of land than a tractor, max 10 ha (Rydberg and Jansén, 2002). As mentioned before this means more reliance on manual labor workers, However as the majority of labourers in the UK agriculture are sourced from within the EU, this free movement of labour may soon be impossible if the UK leaves the European union (Randall and Bishop, 2019).

2.1.1.4 Possible future sources of traction

If animals are not an economically feasible environmentally sustainable alternative to the combustion engine tractor, then perhaps another solution would be to consider an alternative. A solution may then be to attempt to increase the renewability of the energy sources for the tractor through biofuels or electric tractors. Electric tractors are in development with one compact tractor being introduced to the market (Fendt.com, 2019). However the battery technology is not only expensive, costing more than twice the normal price of diesel tractors (Allison, 2017), but the tractors only hold enough charge for operational work of 5 hours. This is estimated at: 1 Ha of heavy duty such as ploughing work per full charge; 20 Ha of light work such as mowing per full charge; or 4 Ha of normal work such as cultivation per full charge (Fendt.com, 2019). Biofuels are more affordable and operational, but this still requires the tractors and their fuel to be imported, or for the neighbouring land to be used as a source of their biofuel. This would be difficult to implement in the UK, where 70% of the UK's land is already being used for agriculture (DEFRA, 2012).

2.1.2 The Co-operative Agriculture model

2.1.2.1 A question of scale

Viticulture is a high risk investment, due to the fact that there may be numerous possible short term losses, whereas the gains are likely to only materialise in the long term. It will usually take around 20 years to pay off initial investments (Savills, 2019). Savills also suggests that to mitigate long term costs the vineyard should have an onsite winery, but this also increases the initial investment capital required making the short term losses only more pronounced (Savills, 2019). There are ways of mitigating this investment by increasing the scale of the venture (Krugman, 1980), where as the quantity of output increases the average cost of production decreases due to factors like more efficient division of labor. However as discussed in the previous section, land is a scarce and expensive commodity in the UK (DEFRA, 2012), and a vineyard with a low environmental costs needs close attention and management, which is harder to do on larger scales.

From the point of social sustainability, scale is important to consider when discussing the ownership of land, and the distribution of wealth throughout the industry. Wealth inequality is an important aspect of social sustainability, as there are clear links between wealth inequality and social well being in all its forms, from mental health issues to crime and productivity on a national scale (Wilkinson and Pickett, 2009). Therefore the business should consider splitting the land into smaller parcels and distributing the "ownership" between many vineyard managers through leaseholds, or other such mechanisms. Alternatively the Cooperate could just ensure that it provides a similar level of economic reimbursement to every level of employee.

A problem then remains: how can "small", individually owned vineyard become economically sustainable on a global market?

2.1.2.2 Cooperative agriculture

A Cooperative union of farmers can offer:

- A pool of shared machinery; or stables to breed, house, and maintain horses as well as ploughing equipment and a pool of shared knowledge for best practices (Ortmann and King, 2007).

- A shared manufacturing and marketing department. One of the greatest challenges for individual businesses is to compete in saturated markets with established brands (Johnson, 2013), investing individually in marketing and manufacturing is costly, but joining together can give small to medium businesses the clout they need to compete (Ortmann and King, 2007).

- A credit union. A joint pool of funds and credit means that farmers can loan credit to members without having to outsource loans to banks which will drain the company of it's profits through loan repayments. This means that each individual farmer will have more direct access to large sums of money needed for investment in their businesses and repayments can be peer-managed, returning loaned money to the shared credit union (Ortmann and King, 2007).

Finding investors may be difficult, but Cooperative viticulture is widespread across Europe (Robinson, J. 2006), with many cooperatives having lasted for centuries through many periods of economic hardship (Johnson and Robinson, 2013). The Cooperative can also supply a centralised cellar for the vineyards all to share, which means that the initial investment required by the viticulturist is lowered. In addition the profits of each harvest are kept within the union, which can be invested back into the union in various ways, helping to mitigate long term costs and be more economically sustainable (Savils, 2019).

2.1.3 An English Appellation

Another idea to consider, which might compliment the use of cooperatives, is the "Beneficio" system which is used in the the Douro valley. The Douro valley has been a historically successful wine region, which has been exporting Port wine to England, France, Germany and the Netherlands for centuries. The "Beneficio" system is a system of valorisation of terroir which rewards good (and therefore expensive) farming practices and protects the income of small grape producers (Fonseca, 1949). This system has provided an economic incentive for businesses to use practices that produce a higher quality product, and protect the commercial sustainability of the area and the industry. A study in Italy has shown that the reconstruction and/or restoration of traditional cultural vineyard landscapes is not only economically sustainable but profitable for local farmers (Torquati, et al., 2015).

Though I will not discuss it further here, it might be an idea for future papers to look into the creation the UK's first appellation. The UK is yet to create an internationally recognised appellation, or governing body of said appellation. Therefore, it might be prudent that in the inevitable creation of such an institute to propose the inclusion of a benefits system in the rules. This would be a massive undertaking on a national scale, but such cooperation could help create a region wide sustainable system of viticulture.

2.1.4 Organic viticulture

When talking of environmental sustainability most viticulturists will choose to adopt practices that come under the term “Organic”. The European Commission defines ‘organic farming’ as “an agricultural method that aims to produce food using natural substances and processes” (European Commission, 2019). The legislation was introduced in 2007 and recently the Commission has passed legislation to update the terms of organic to create a better legal framework for the rapidly growing sector (European Commission, 2019).

Over years of study however, Organic agricultural/viticultural practices, just as standard/non-organic practices, still have an environmental cost. Soil structure in many vineyards has improved by some metrics: soil organic matter, potassium content, soil microbial biomass, plant-feeding and fungal-feeding nematode densities (Coll et al., 2011). However, the same study shows that conditions have worsened by other metrics: increased soil compaction, decreased endogeic earthworm density; and no change to the soil micro-food web evaluated by nematofauna analysis (Coll et al., 2011). That is not to say that organic viticulture has failed, by contrast studies in Italy have shown that when compared with conventional vineyards, organic vineyards tend to be more environmentally sustainable (Strano et al., 2013; Niccolucci et al., 2008).

Organic farming has shown mixed results in increasing the biodiversity, but a meta-analysis of data before December 2002 shows that on average organic farms have an increase in birds, predatory insects, soil organisms and plants but a decrease in non-predatory insects and pests (Bengtsson J., et. al., 2005). The effect this has on ‘agroecosystems' is significant, since the majority of renewal processes and ecological services are largely biological and delicately balanced (Altieri, 1999). Therefore a return to ‘minimal interference’ viticulture is possible, but needs to be carefully implemented. One example of a measure intended to protect the environment, which had unintended consequences, was the EU’s decision 5 years ago to ban neonicatinoids, a category of pesticide which has devastating effects on the bee population (Woodcock et al., 2017), this ban has also been linked to a rise in the population of a beetle which eat oilseed rape (Gray, 2014).

European legislation requires all farmers who wish to have Organic certification, to limit the amount of additives on their land in order to reduce effluents caused by run off and rain (ec.europa.eu, 2008). The legislation does not require them to treat or even monitor the amount of effluent that comes off their land (ec.europa.eu, 2008). Streams around the vineyard will contain increased levels of pesticides and other agrochemicals during flooding season (Rabiet et al., 2010) The South East is becoming increasingly prone to flooding risk (GOV.UK, 2019), therefore a vineyard should attempt to control and treat drainage and run-offs from the soil.

2.1.5 Incorporation of animals into vineyard management

Other radical techniques such as ‘permaculture’ or ‘rewilding’ are notable attempts to increase biodiversity in farming. There is global precedent for permaculture being a successful method of farming, but until recently it has relied on mysticism and hearsay for sources of practice rather than science (Ferguson and Lovell, 2013). However, research into permaculture, and it’s merging with agroecology, is providing interesting findings and can be useful for the development of sustainable viticulture (Ferguson and Lovell, 2013).“If it were possible to distill the agroecological content of the permaculture literature into a single thesis, it might appear in this way: with systematic site design, emphasising diversity at multiple scales, integrated water management, and access to global germplasm, we can increase the productivity demonstrated by heritage agroecosystems - especially labor productivity - while retaining their most desirable attributes of sustainability and multi-functionality.” (Ferguson and Lovell, 2013).

Rewilding is a concept that, up until recently, was uniquely applied to conservation of endangered species or the study of abandoned areas of Europe such as Chernobyl (Navarro and Pereira, 2015). Recently however, is has regained traction as a credible solution to the biodiversity crisis now facing agriculture across the globe (Rey Benayas and Bullock, 2015). The idea is not new but important. By reintroducing designated areas of woodland or hedgerows, we can provide habitats for natural flora and fauna to develop, this in turn can benefit the neighbouring agricultural land by increasing biodiversity, with all the numerous benefits that entails (Rey Benayas and Bullock, 2015).

The Knepp Estate, in West Sussex, UK, is an example of a rewinding project already in action (Tree, 2017). Here, rewilding principles have been combined with ecological concepts to create a balanced, self-sustaining ecosystem with horses, cattle, and pigs (Tree, 2017). The Knepp Estate is now considered one of the most important sites for biodiversity in England, with the return of numerous species of birds, predatory insects, and vegetation which were once common across England and are now endangered (Tree, 2017). If one wished to design a biodiverse vineyard in the UK then we would recommend using the Knepp estate as a good case study for understanding how to implement rewilding into the vineyard.

Incorporating animals as part of vineyard management has been studied in New Zealand and shown to be a viable alternative to constant cultivation or herbicide usage (Dastgheib and Frampton, 2000). This study attempts to establish whether grazing animals can be beneficial for fruitfulness when compared to herbicide applications. Though this study’s results show that a reduction of residual soil herbicide coincides with an increase in yield of fruit there are more compelling reasons to reduce herbicide applications, for instance the leaching of certain herbicides into groundwater systems (Landry, et al., 2006).

Grazing livestock, such as sheep, are widely used for conservation management of grasslands, as their constant grazing and browsing keeps fast growing plants under control and encourages biodiversity of sward and grasses (Popay and Field, 1996). Though the presence of grazing herbivores can be useful to control weeds, it should also be acknowledged that livestock can also be just as damaging to vineyards as highly mechanised farming. For instance larger, heavy grazing of sheep can cause serious soil compaction and prevent herbaceous growth (Pulido et al., 2017). Similarly when livestock are regularly treated with avermectin to prevent intestinal parasites, there have been noticeable drops in the presence of British dung beetles, who's primary role is to digest sheep droppings into an available form of nutrients for plants. Without the presence of these dung beetles, the dung crusts over and plants are unable to penetrate the crust (Wardhaugh and Mahon, 1991). Therefore it becomes necessary for the Viticulturist to understand how the sheep are reared, this can either be accomplished by having a close relationship with a local shepherd or for the company to hire and rear their own sheep. Additionally the introduction of sheep into a vineyard requires infrastructure such as electric fencing and sheep gates if a public footpath is present.

Some vineyards use mechanised cultivation techniques to control under vine growth of weeds or sward. This was believed to reduce competition for nutrients between the vine and the sward, thus increasing yield or vigour of the vine (Hostetler et al., 2007). This mechanised crop management has lead to an increase in soil erosion within the vineyard, the main vector for this erosion is rainfall shifting loose topsoil in Mediterranean climates (Martínez-Casasnovas and Sánchez-Bosch, 2000). The UK, being. a temperate island climate, tends to have a higher annual rainfall than most Mediterranean climates (En.climate-data.org, 2019). Therefore, it is even more important when designing a vineyard in the UK to consider the best ways of minimising soil erosion. One such method would be to not use mechanised cultivation techniques to control growth of weeds or sward. In addition to the dangers of over mechanisation, it has been shown that keeping a layer of sward under the vines can increase the level of anthocyanins, the phenolic potential of the grapes, as well as reduce acidity (Monteiro and Lopes, 2007).

2.2 Incorporating sustainability into the design of the vineyard

2.2.1 The soil profile

Soon after acquisition of a plot of land a decision has to be made regarding the planting. It is prudent to understand the climatic profile of the plot. This means soil analysis, weather mapping, and a topography map amongst many other things. This is done to create a soil profile in which the viticulturist can better understand the land and work with its advantages, and mitigate the effects of disadvantages, by choice of cultivar, rootstock etc.

2.2.2 Diseases, pests, and other crop risks

In the UK, according to the Royal Horticultural Society there are very few viruses affecting grapevines, and Xinefima index is not a threat and thus immediate preparation against the nematode is very often not necessary (RHS, 2019). The soils type around Kent tends to be well drained; non-calcareous; fine loamy soils over limestone at variable depths; slight to moderate acidity (pH between 5.6 - 6.5) (Soil survey manual, 1993); and low to medium levels of soil nutrients (Cranfield University 2019). This means that despite the presence of limestone, it is unlikely that limestone chlorosis of iron will become a serious problem due to the acidic soils (Mengel and Geurtzen, 1988).

Drought is also unlikely to be a problem due to high rainfall and high levels of available ground water (Cranfield University 2019). However the high levels of rainfall bring risk of fungal infection from botrytis and mildew (Fitt, et al., 1985)(Willocquet and Clerjeau, 1998).

2.2.3 Cultivar selection

Though soil type is one important variable to consider when deciding upon a rootstock, often the most important choice is the synchronicity between rootstock and scion (Martínez-Ballesta et al., 2010). Climatic temperature, specifically the Winkler index (Winkler, 1974), often dictates the best choice of scion but sometimes it is more important to consider what is fashionable at the time of planting, because cultivars are now considered similar to brands for the customer (Mullen, 2019). Unfortunately, the UK cannot claim to have indigenous or signature grape varieties yet, unlike their European neighbours of France and Germany. Even the famous Bacchus variety, which provides a complex low acidic flavour similar to Sauvignion Blanc, is a German cross breed (Robinson, 2006). Therefore there is not yet a specific style to English wines. This lends opportunity to new producers to do whatever they feel might be best for their company, whether new and experimental or old established styles.

Future research might be done into the discovery of an “English” style of wine, rather than copying existing styles of wines such as Champagne, but that is for a later date, many new world countries still haven’t found their own style and Bordeaux was not built in a day. An interesting idea might be to take lesser known cold climate varieties such as Alverinho from Vihno Verde region of Portugal, or expand into German varieties. Perhaps an “international blend” of Portugal, France and Germany to mirror England’s history of multiculturalism, international trade and a non-conformist attitude towards innovation and experimentation.

3. Proposal for Vineyard design

3.1 Objectives of the Vineyard

The environment is becoming increasingly delicate and the need for industries to take responsibility is evident (Signals, 2016). Sustainable viticulture requires, more than anything, to focus on environmental sustainability due to our rapidly changing climate (see section 1.1). Viticulture in the UK, though not entirely new, is yet to be properly established and there is therefore plenty of freedom for viticulturists. As a new and emerging vineyard we would suggest taking radical moves towards environmental sustainability, beyond the titles of Organic or Biodynamic. Choosing a plot is the most important step, if climatic or soil analysis shows that the plot is lacking or deficient in any way then it is best to find another.

The key objectives for the Vineyard in the paper are:

- As discussed earlier, in terms of emergy, efficiency, and environmental sustainability, the ideal choice of traction when choosing from our current range of technology, from an environmental perspective, would be to return to the usage of animals such as horses in order to reduce reliance on fossil fuel tractors. Also, for the reasons discussed above, there are important environmental advantages to be gained from returning to a more biodiverse farming structure.

- The vineyard should be planted with the goal of introducing permaculture or rewilding. The development of agroecology for pest control, soil nutrient balance and choice cultivar selection can negate the need for invasive - and labour intensive - agricultural practices while also creating useful side products, such as wool from sheep or honey from bees. There is little research on how to best incorporate this into a vineyard and will require the viticulturists to outsource expertise from other areas of knowledge.

- The model for this vineyard will be based on a small plot of 22 ha total size. As mentioned above, the focus of this vineyard is to maximise the environmental sustainability, which would currently be best achieved through the use of horses for traction power, as serious alternatives to fossil fuel powered tractors. As previously discussed in section 2.1.1, using horses would require a different layout and design to a vineyard designed to be maintained by tractors. The vineyard will also look to minimise the use of chemical spraying, because, as discussed in section 3.5, aggressive spraying can also be environmentally damaging.

- This vineyard will assume the existence of a centralised cooperative with a cellar that will make wine. This will save the each individual viticulturist on cellar running costs.

- This vineyard will also endeavour to establish a Kent style wine to help establish an appellation for the region of Kent within the UK, with the hope that aspects of Champagne and Douro valley will be incorporated to help protect the sustainability of the region, as discussed in section 2.1.3.

- In order to create this distinctive style, this vineyard will use the following cultivars:

  - Pinot Meunier, due to its blending potential, it is undeniable as a key ingredient in Champagne wines;
  - Verdejo, because of its dry acidic profile with high oxidising potential, and for its versatility as part of a blend with other grapes;
  - Bacchus, due to its status as a staple of English White Wines, and as a terrific base wine that can be used for any tier of the market;
  - Alvarinho, an excellent base wine which can be blended into higher quality wines, high yield and suited for humid cold climates;
  - Seyval blanc, a highly resistant variety which provides good acidity for blending into still or sparkling wines;
  - Regent, for red or rosé wines, as a variety which is resistant to mildew, and that has a very unique character. As of yet, it is a cultivar unclaimed by any other region, perfect for creating a 'Kent Style Red' (Ganesch, 2019);
  - Chardonnay, a high yield, highly commercial wine for still or sparkling blends;
  - Pinot Noir, highly commercial red for blending into reds or sparkling white wines;
  - Rondo, resistant to mildew red, similar to Regent but is also colloquially known as "Kentish Claret" (Ganesch, 2019).

3.2 Climatic overview of Kent

The World Atlas of Wine 2013 edition, calculated the Winkler Index for East Malling to be 1562, placing it firmly in Region Ia, capable of growing early ripening varieties (Robinson, 2013). Using weather data gathered from East Malling weather station (see appendix), approximately 5.5 km from chosen planting site, using an average value from the years 2015-2018, we have calculated an average Huglin Index value of 1419 and an average number of 1204 sunlight hours during the growing season. This value itself is too low to grow even most early ripening grapes (Huglin, 1978), however the huglin index of 2015 is vastly lower than 2018, which increased from 1211 in 2015 to 1594 in 2018, almost warm enough to grow pinot blanc and gewürztraminer (Huglin, 1978). The site itself is on a south facing slope and enclosed by trees and on heavy clay soil with occasional flint stones, each of these factors are commonly associated with increased ripening and high quality terroir, though the precise scientific impact is still not conclusively understood (Van Leeuwen and Seguin, 2006). Though this is not very precise, it is supported by neighbouring vineyards which easily ripen Chardonnay, Pinot Noir, Rondo and Regent grapes.

There is a slight frost risk, usually around mid to late April where temperatures approach or drop below 0°C, in order to combat this it will be necessary to keep ground sward at a low level, or to otherwise encourage airflow throughout the canopy (Ingels, 1998).

The same weather station provides information on rainfall which is 295 mm total during the growing season. Unfortunately without complimentary information, such as the water retention of the soil, we cannot make many conclusions based on this measurement alone. Since this is a new site, parameters such as evapotranspiration of soil and vines have not been measured, so there is no way to calculate the potential water deficit of the vineyard. However, as observed in figure 1, the rainfall around this area is fairly regular in frequency, if irregular in quantity, during the growing season. A viticulturist could see this and surmise that a need for irrigation is unlikely, but climate change tends to decrease the number of days of rain, while increasing intensity of those days of rainfall, as seen in the pattern of 2018. We would recommend the viticulturist to asses evapotranspiration within the vineyard to ensure the longevity of their vines. This should not occur until the fourth year of planting, in order to obtain a more accurate picture.

Sudden and heavy rainfall can lead to flash flooding of lower terrain, but since the lowest point of the vineyard is roughly 60m above sea level, and higher than the surrounding terrain, the flash flood itself is not an immediate threat to the vines. The heavy rainfall that can lead to flash flooding will also cause serious soil erosion, and the vineyard must be designed with this in mind.

We would recommend the installing of a weather station at key strategic points in the vineyard to understand the true ripening capabilities of the vineyard, but this can be installed after planting. This weather station could also be used in conjunction with predictive modelling patterns to develop spraying strategies targeting the prevention of harmful fungi in the vineyard (Madden et al., 2000)

3.3 Soils of Kent

The soil analysis was provided by a UK wine company who has chosen to remain anonymous for this paper but they have given their expressed consent to reproduce in full the analysis of the soils for the site. See the Appendices for these reports. In summary the soils are highly alkaline with relatively low levels of nutrients throughout, this is to be expected due to the high presence of chalk in the area.

An extensive soil analysis has been carried out for the key nutrients and pH (see appendices). The soil appears homogenous on first inspection, the levels of nutrition are varied, with higher concentrations appearing at the base of slopes. It is important for the viticulturist to note that the pH is rather high, between 7.8 and 8.1. A pH at this level will affect the availability of many key nutrients and may trigger chlorosis in many vines (Marschner et al., 1987; Mengel, 1994). Therefore the addition of acidifying agents during the soil preparation stage would be necessary, such as Fermented silage, and the selection of a hardy rootstock, well adapted for chlorosis should be selected, such as Fercal (Galet, P. 1988).

Another key feature is immediately noticeable from the soil nutrient level maps: the south east corner of the plot seems to contain unnaturally high levels of Potassium and Phosphorous. This is likely to have been caused by spillages of previous farmers and is unlikely to lead to healthy vines. Therefore we suggest that the viticulturist dig out the area for at least a meter deep, and convert it into a reed bed. This reed bed can be connected to the various drainage systems in the vineyard, which can help prevent local water course pollution from potential effluent.

3.4 Designing the Vineyard

Figure 1: Aerial view of the site with topography

The Total Size of the Vineyard is 22 hectares including tree lines and wild-land. We propose parcelling the land into 3 sections with a total of 8 vineyard plots. The sections will be roughly 3-4 hectares each and separated by thick hedgerows as seen in figure 2. Drainage will need to be installed in the first year of purchase, before fallowing, or deep ploughing the land. This drainage should lead to a reed bed as shown figure 2, which will act as an effluent treatment plant, metabolising any contaminate before heading through a carbon filter and back to the national water course. The drains themselves will all need to be underground french draining to prevent injury to sheep/vehicles which may need to traverse them, save for the main drain running along the southern end of the vineyard, which should be open and deep to cater for heavy rainfall in the winter. The reed bed could be situated in the south east corner, the aforementioned site of contamination, since it is in the lowest point of elevation in the site.

The green section highlighted are proposed hedges and wild lands to naturally encompass the vineyard. This 5.8 hectares of managed lands should provide habitat for indigenous bird and insect life to thrive and encourage biodiversity. The Vineyard can use this to turn previously unsuitable ground into a source of revenue from EU subsidies for nature conservation.

The distribution of Cultivars suggested are as follows;

Plot 1: Pinot Meunier (0.72 Ha) and Verdejo (1.08 Ha), (mix of 30%:70%)

Plot 2: Bacchus (2.76 Ha)

Plot 3: Alvarinho (1.14 Ha)

Plot 4: Seyval blanc (1.30 Ha)

Plot 5: Regent (1.41 Ha)

Plot 6: Chardonnay (2.16 Ha)

Plot 7: Pinot Noir (1.39 Ha)

Plot 8: Rondo (1.33 Ha)

3.5 Key problems and their possible solutions

The majority of agriculture in the UK is arable farming (DEFRA, 2012), so when purchasing land it is important to consider what damage may have been done to the soil by the previous owner of the land, and how best to manage the soil in order to rectify it (Reganold et al., 1987; Havlin et al., 1990). Common problems include compaction of the soils from over usage of machinery (arable farming is very machine heavy) which can also lead to water logging issues and the necessity of improved drainage. Soil compaction can limit root exploration and thus has major health implications for the plant due to lack of available nutrients and water (Taylor and Brar, 1991). If left unmanaged water logging can encourage fungal and bacterial growth, which can increase the risk of infection post pruning for the vines (De Curtis et al., 2012).

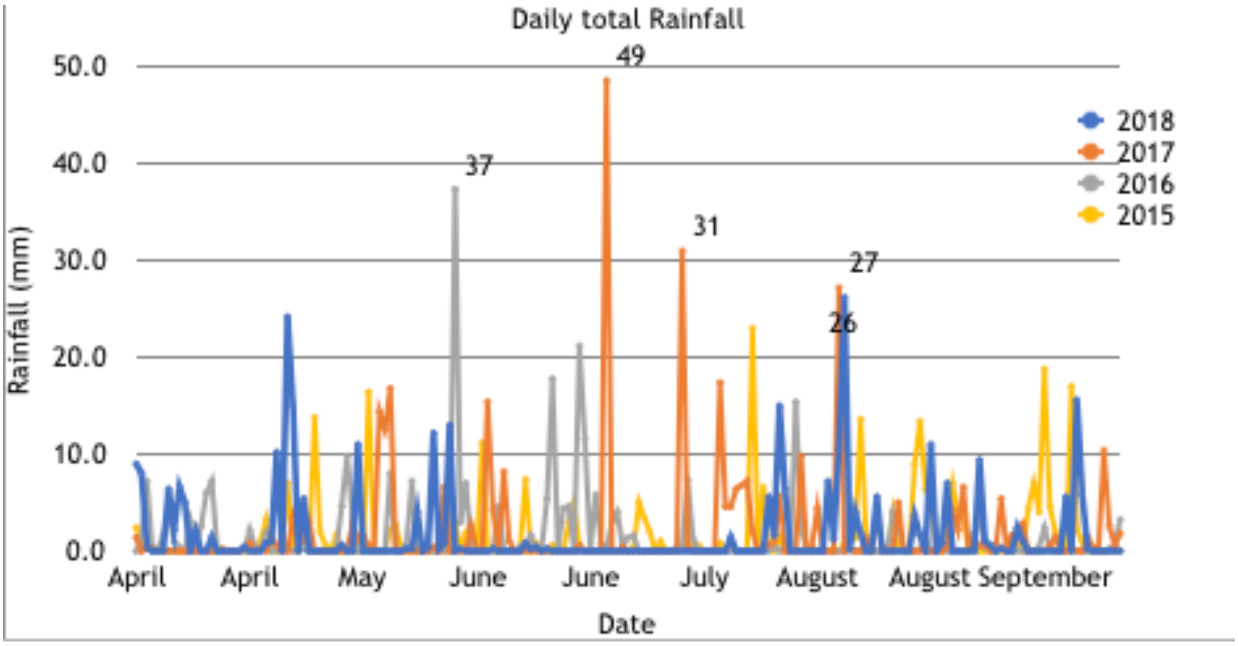

Figure 2: Weather data from East Malling, MET office, (see Appendices)

An interesting natural solution to soil compaction is to plant strong deep-rooted plants, such as cereal rye and turnips, to naturally break apart soil and help with water-logging in a process referred to as 'biodrilling' (Williams and Weil, 2004). This process is time consuming and will cut greatly reduce the speed of the return on the investment. Given the scale of the investment, it is important for the vineyard to be producing fruit as soon as is practically possible in order for the business to be profitable. Therefore, this is only a viable option for existing companies undergoing a gradual expansion.

More practical solutions include deep farrowing, or injection of pressurised air to break compacted soils (Unger and Kaspar, 1994). The machinery required for breaking up the soil is, relatively cost efficient, and deep farrowing can be done by a tractor.

Water-logging is a serious problem in the UK, partly because of the heavy amounts of rainfall per annum, but mostly due to soil compaction from the mechanical techniques of arable farming (Posthumus et al., 2011). Theoretically, once soil compaction is fixed the water logging problem should also be fixed, but this is not always the case in practise (Batey and McKenzie, 2006). Due to heavy rainfall it may be necessary to invest in drainage systems for plots of land which do not have an incline. A simple solution would be to introduce a series of hallows and farrows with a ditch dug around the vineyard as a form of surface drainage.Alternatively more deep soil techniques could be implemented, such as a 'French drain' - a tunnel of porous rocks which encourage an underground stream that drains the deeper soil.

Whichever drainage solution is selected, it would be important to monitor the additives to the soil and soil pH. This is because the run-off water may have dissolved acids or ammonia, which can contaminate nearby water ecosystems with severe consequences on fish/plant life (Buol, 1995; Klimaszyk and Rzymski, 2010).

One solution to local water pollution caused by agricultural run off would be to invest in a water treatment system at the base of each drain or vineyard. A constructed wetlands area would be one way of achieving this, which might be more cost effective than most would think (ITRC, 2003). Constructing an isolated wetlands at the base of a vineyard allows marshland grasses and reeds to uptake all excess nitrogen and phosphate ions in the run off soils, helping to prevent eutrophication in adjacent water ways (Cottingham et al., 1999). The disadvantage to this low cost and sustainable solution to waste water treatment is that it requires more land, which is a scarce resource in the UK.

The nutrient deficiency of new plots of land can be addressed by the addition of fertilisers, natural manure, or artificial ammonia, to adjust nitrogen content. Nitrogen is a key element in plant growth (Conradie and Saayman, 1989). This requires special attention though since the addition of ammonia or manure changes the pH of the soil and can cause difficulties in nutrient uptake and chlorosis. This is especially common since arable farming often leaves soils with very low pH though over usage of fertilisers and manure.

Vineyard rootstocks absorb key soil nutrients in a specific pH range , which means that some adjustment of the soil pH will always be necessary. This is complicated by the fact that methods for managing soil pH are often ineffective at a subsoil level. The addition of Lime into the soil can increase the pH of soils and there are some studies which show positive results, however it is also a very expensive process and the long term effects of liming are poorly understood (Haynes and Naidu, 1998). An alternative might be to plant the field with a mix of legumes such as clover for a year or so beforehand, with cultivation to increase organic matter in the top of the soils. This has the added benefit of increasing microbial biodiversity of the top soil. If used without tillage the soil can develop a beneficial fungi such as Arbuscular mycorrhiza, this fungus works in symbiosis with vines and legumes to increase nitrogen fixation and nutrient uptake among other things (Parniske, 2008). However mycorrhiza is an incredibly delicate fungi that does not survive deep cultivation or spraying. Further research is needed on the subject of surface cultivation but current evidence suggests surface tillage may be beneficial for the growth of mycorrhiza (Trouvelot et al., 2015).

Plant density will vary with variables such as cultivar and climate, therefore it is too difficult to recommend an exact plot for every vineyard in the UK. But the main defining difference is the choice between mechanisation or old fashioned manual labor. With mechanisation the distance between rows is determined by the width of the tractor but with old fashioned manual labor one is able to have increased density plots for higher vine competition and greater yield per hectare (Hedberg and Raison, 1982). Due to Britain’s naturally wet and nutrient rich soils, it might be prudent to suggest that a denser plot is needed to increase competition between vines and create artificial water and nutrient scarcity (Intrieri, 1987). However the effect of vine density is somewhat disputed and current scientific data would suggest there is little effect in nutrient rich soils, and that the best method used to decide density is desired production (Reynolds et al., 2004; Bernizzoni et al., 2009)

Another problem associated with wet soils is if excess moisture was to remain on the plants then the vines would become susceptible to rot and other pathogenic fungi such as botrytis or black rot (Hocking et al., 2007). This can be avoided using fungicide spraying but excessive spraying has been found to cause health problems for vineyard workers (Fitzmaurice et al., 2014; Dennis et al., 2010). Though not all pesticides and fungicides are linked with health concerns, there is enough evidence to encourage viticulturists to exercise caution in their choice of sprays and spraying practices (Austin et al., 2001).

Since there are few sunlight hours in the UK for the majority of the year the best thing to dry out the vines is wind (Currentresults.com, 2019). This means to avoid disease pressure it is necessary to ensure a decent wind flow throughout the canopy, which means leaf removal and special attention to be paid to row orientation to protect from excessive wind speeds. Unfortunately the UK has a unique weather situation in which it is an island with five main prevailing winds which supply it's weather, all from different directions. This makes the climate in the UK difficult to predict, and wind can come from more or less any direction for any given day (Czerski H., 2012).

Therefore, I believe row orientation should follow the standard North to South orientation where possible in order to homogenise what little sun exposure the UK can provide. Exceptions may be necessary in specific instances were the incline of the ground does not accommodate for safe tractor driving. Wind speeds rarely pick up to a point of breaking vines in the UK, but just in case the best option may be to have the vineyard in a protected environment with hedgerows protecting the crops to prevent gale force winds. The hedgerows will require plenty of trimming, hedging, and leaf removal, around the vines to maximise a gentle airflow within the canopies (Vasconcelos and Castagnoli, 2000).

The vineyard should also look into available conservation stewardships in the UK, which offer subsidies for the protection of biodiversity and endangered species (GOV.UK, 2019). This scheme includes the management of hedgerows and diversity of nectar rich swards, which are beneficial in and of themselves in a vineyard but expensive to implement and maintain (Benayas and Bullock, 2015). Relying on a stewardship such as this can help with initial investments in planting nectar rich swards and hedgerows, with £511 per Ha per annum for swards and £8/100m for hedgerows (GOV.UK, 2019). The hedgerows could also produce an income of their own if they were lined with Blackberry bushes, an indigenous fruit.

3.6 Cost of installation

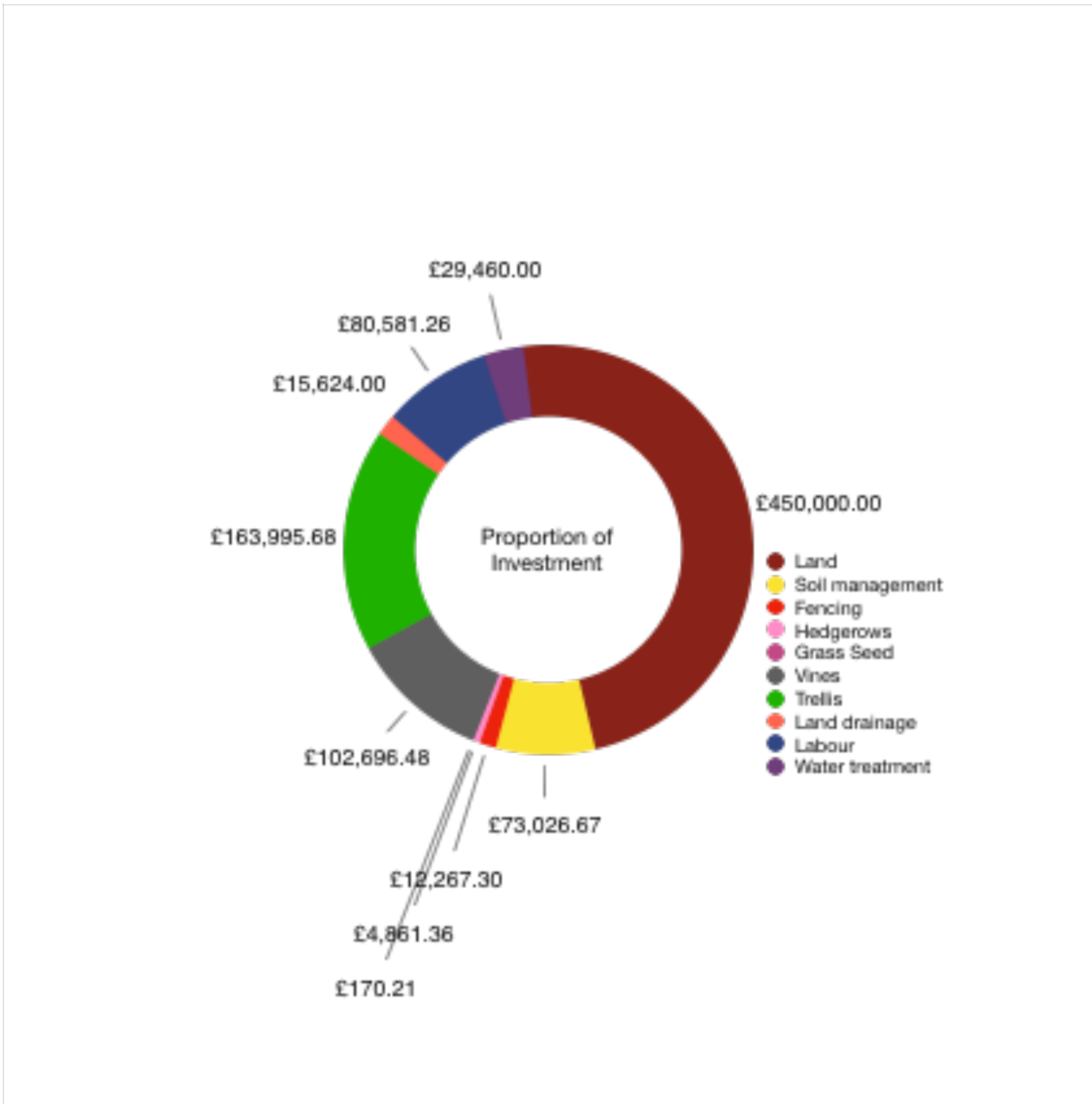

Figure 3: Visual representation of Proportion of investment.

3.6.1 Calculating total cost of the Vineyard

Table 1: Initial investment and references used for calculation

Cost	Initial Investment	Net Per anum income (From government grants or sales)	Cost/benefit	References
Land	£450,000.00	£4,454.98	-£445,545.02	(OnTheMarket, 2019)
Soil management	£73,026.67	£0.00	-£73,026.67	(CPA, 2019; The Farming Forum, 2019; Agri-gem.co.uk, 2019)
Fencing	£12,267.30	£0.00	-£12,267.30	(Gallagher Europe, 2019)
Hedgerows	£4,861.36	£120.00	-£4,741.36	(GOV.UK, 2019; Ashridge Trees LTD, 2019; see appendix 7)
Grass Seed	£170.21	£6,775.86	£6,605.65	(farmseeds.co.uk, 2019; GOV.UK, 2019)
Vines	£102,696.48	£287,513.78	£184,817.30	(UK Vine Care Ltd, 2019; See appendix 8)
Trellis	£163,995.68	£0.00	-£163,995.68	(UK Vine Care Ltd, 2019; See appendix 8)
Labour	£80,581.26	£0.00	-£80,581.26	(UK Vine Care Ltd, 2019; See appendix 8)
Land drainage	£15,624.00	£0.00	-£15,624.00	(White Horse Contractors Ltd, 2019; See appendix 9)
Water treatment	£29,460.00	£0.00	-£29,460.00	(Farmers Weekly, 2019; GOV.UK, 2019)
Managers Salary	N/A	-£25,000.00	N/A	
Vineyard operative salary	N/A	-£20,000.00	N/A	
Membership fee	N/A	-£1,000.00	N/A	
Business Expenses	N/A	-£10,000.00	N/A	
Total	£932,682.95	£242,864.63		

3.6.2 Breakdown of initial investment

The total cost of installing this vineyard is £932,682.95, including the acquisition of land. A loan could be taken out in order to mitigate the amount of capital needed to buy the vineyard. This total cost does not include the first two years after planting where the vineyard would still need to pay for salaries and other expenses such as spraying chemicals and other vineyard equipment, and for the theoretical membership fee to remain part of the proposed co-operative. As shown in Table 2, this is a further cost of £89,298.31 to be accounted for until the fourth year where the vineyard can be considered to be running for a profit, assuming an annual yield of 14 tonnes per Ha, an assumption explained in section 3.7.

Table 2: Return on investment

Year	Debt at the start of the year	Annual Income	Remaining Debt at the end of the year	Cumulative Income	interest (5% APR)
1	£932,682.95	-£44,649.16	£977,332.11	-£44,649.16	£48,866.61
2	£1,026,198.71	-£44,649.16	£1,070,847.87	-£89,298.31	£53,542.39
3	£1,124,390.26	£41,604.98	£1,082,785.28	-£47,693.33	£54,139.26
4	£1,136,924.55	£214,113.25	£922,811.30	£166,419.92	£46,140.56
5	£968,951.86	£242,864.63	£726,087.24	£409,284.54	£36,304.36
6	£762,391.60	£242,864.63	£519,526.97	£652,149.17	£25,976.35
7	£545,503.32	£242,864.63	£302,638.69	£895,013.80	£15,131.93
8	£317,770.62	£242,864.63	£74,906.00	£1,137,878.43	£3,745.30
9	£78,651.30	£242,864.63	£0.00	£1,380,743.06	£0.00

3.7 Projection of return on investment

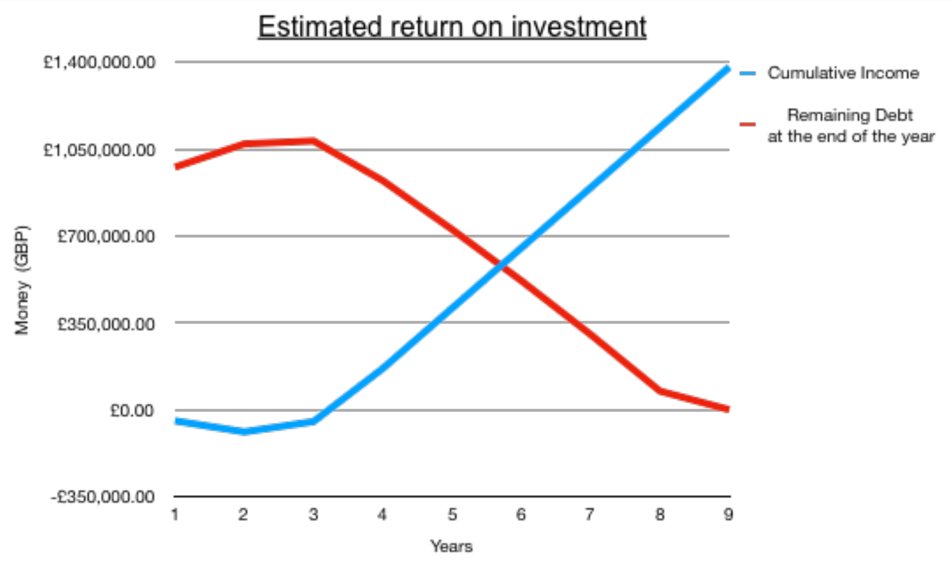

Figure 4: An estimation of cumulative income, demonstrating the economic viability of the vineyard

Vines typically do not provide their first crop until the second year after planting, therefore the farm will not be able to make profit from the vines for at least two years. The first year of production is generally greatly reduced to around 30% of actual yield and second year is estimated at 90% (Savills, 2019).

There isn't a lot of information on the average yield per Ha for Kent as a region, and over the last ten years it has been shown to increase year on year (WineGB, 2018). Currently the average across the the region is 4.46 T/Ha, but this is taking in account different varieties and planting densities. Vineyards of densities of more than 4,000 vines per Ha, similar to the suggested plantation density of 4545 vines/Ha, on average produce 10.97 T/Ha (WineGB, 2018). However most vineyards on the year of 2018 have reported a harvest of 10-17 T-Ha in a bumper harvest crop (WineGB, 2019).

Even assuming a generous estimation of 14 T/Ha for this Vineyard, 13.29 Ha gives us 187 tonnes of grapes.

Then assume that the grapes will sell to the cooperative cellar for £1,500 per tonne for still wine grape and £2,500 per tonne for sparkling (Nix and Redman, 2015).

A generous estimated gross profit of £287,513.78 per annum from grapes was calculated.

In addition there are various government grants which are bespoke to the scoring of your vineyard but are paid annually and can be paid before installation, so this grant will help bare the burden of costs during first three years after planting when the vineyard is only making a loss (see Table 1). This grant is an estimate based on individual key options available to all farms, the annual figure in reality will be different as the scheme requires a bi-annual inspection of the farm where a surveyor will quantify the total impact the farm has on the surrounding environment, and will likely be much higher than the estimated.

Estimated projections for a vineyard of this model show that this vineyard will make a full return on investment in 9 years, assuming an annual interest of 5% on the initial investment and all of the capital is acquired upfront. A loan could be acquired from the agricultural co-operative in order to help acquire the initial capital to buy the land, or even further costs, but paying off this loan will affect theoretical return on investment. The vineyard can be run for a profit after the 3rd year, assuming an “average” yield for its density is achieved in every year (WineGB, 2018). In bumper harvests of 17 T/Ha, the vineyard can expect an annual income of up to £302,218.84 (WineGB, 2019). In years of scarcity, where the region average of 4.46 T/Ha was used for calculation, the vineyard can expect an annual income of £46,352.68 (WineGB, 2018). This uncertainty of profit will be relevant to prospective investors if they choose to take out a loan, as this will inevitably affect the estimated time for return on investment.

The projection also only uses income from government grants and grape harvests, the vineyard may also have additional income from the sheep, honey, blackberries etc that it can also sell. We have not calculated this income since it is focusing specifically on the vineyard and the running costs. Considering the uncertain nature of grape harvests it may be prudent to further invest some of the excess annual capital from the net profit of the vineyard into these additional projects. In order to increase the annual income from the vineyard it could be possible to reduce the number of plots and increase planting density, but as discussed above this will affect the quality and sustainability of the plot.

4. Summary

4.1 Conclusions

The profits from selling the grapes alone is enough to support a small vineyard as a monoculture independent business. Although the viticulturist is presented with two real choices, to attempt to compete on an industrial scale as a single company, or to form a cooperative with other smaller vineyards and farmers and follow a mixed farming approach to viticulture. The former is the current trend in the UK with very few large companies competing in a small market, which only makes it more hostile for the individual farmers. It is possible for the Vineyard to attempt to become a fully self contained wine producer with their own cellar, which can help mitigate long term costs but this requires even more investment and a much larger risk if the wine itself does not sell.

Environmentally sustainable practices are costly, but there are governmental mechanisms in place to fund these practices that can even be profitable for the vineyard. A solution could be to become a complex ecosystem with multiple products, rather than a monoculture commodity production site. There is a very limited amount that can be done to ensure a socially sustainable vineyard other than providing the local area with well paying jobs. This again puts more financial strain on smaller farms, and with the current price of grapes, the farms would not be able to pay a decent wage for more than three employees for every 10 Ha. The only way to accommodate the existence of profitable and sustainable farms within the model of capitalism is to create an agricultural cooperative which has mechanisms in place to distribute labour, tools and wealth between many farms. It is also suggested that to increase economic sustainability the vineyard should try and consider multiple sources of income such as sheep, beekeeping, government subsides as well as relying on an agricultural cooperative to help shoulder the burden of investment and provide workers.

Tractors provide significantly more traction per unit of surface area, and are less labour intensive per unit of surface area. However, horses require a lower level of emergy use, and are cheaper per hectare than the tractor. The lower emergy use, as explained earlier, is a huge ecological advantage, but also points to the general efficiency of using a horse instead of a tractor. There is no catch-all solution, only bespoke approaches for each individual case. To suggest that vineyards return to using horses would require a total overhaul of how we perceive agriculture (see section 2.1.1). Not only would this affect the vineyard but it would also will require a change in the surrounding environment, and this should be considered by every viticulturist before planting (see section 2.1.1.4).

We have shown that the cost of this vineyard is high but a return of investment within 10 years, assuming a good harvest. As discussed in section 3.5, this business model is reliant on the Government subsidies available to encourage certain ecological agricultural techniques. The high levels of investment required, and the relatively long wait for a return of investment, are obstacles to many businesses choosing to employ this model of vineyard. Therefore, it is imperative to create a governing body which can implement and enforce policy decisions designed to increase sustainability and stability, thus creating a level of economic parity between companies.The UK is sorely in need of a regulated, regional appellation, but it does not yet have a distinctive style of wine nor a body to regulate production. The creation of a central body which has economic powers to grant status to vineyards with sustainability incorporated into their practices such as a recognised label of “Wines of Kent” or simply just “Kentish wine”. This could be achieved through Government legislation (for example via a Statutory Instrument) creating a governing body which has the power to recognise vineyards as meeting a desired standard of quality and sustainable practice. This statutory instrument could also grant vineyards which attain this status the right to claim the necessary subsidies to help their business model to be economically sustainable.

Currently, the Douro Valley and Champagne are the world's only appellations which attempt to use their powers to grant premium status to help maintain the sustainability of the region's industry, and thus should be used as a template for the creation of any and all English appellations.

4.2 Limitations

4.2.1 Future relationship between the UK and the EU:

It is impossible to consider the future of sustainable viticulture in the UK without addressing the effect of Britain's relationship with the European Union. On the 26th of June 2016, the UK held a public referendum with a "in or out" vote to determine it's future relationship with the EU, and subsequently the world. The UK population chose to "Leave" the EU in a result now colloquially known as "Brexit" and the projected leave date was 29th of March 2019. At present, as of writing this paper, the default position in law is for the UK to attempt to further extend the deadline to February 2020 (Services.parliament.uk, 2019). However should the head of state fail to negotiate this with the EU, the UK will leave on a "No Deal Basis" on October 31st, whereby it would automatically have "Third Nation status"(Europarl.europa.eu, 2016). In a "No Deal scenario" trading relationship would be heavily dependent on the tariff systems and structures set out in the WTO (World Trade Organisation) agreements. It is anticipated that this would lead, amongst the many wide-ranging and far-reaching socio-economic ramifications, to an increase cost in both importing and exporting goods.

Wine is a particularly political commodity (EU Commission v UK beer and wine, 1983), and is likely to be more affected by this than most. The EU directly influences UK agriculture in the following ways:

- EU Common agricultural policy. This includes agricultural subsidies received by the EU, import levies on wine from outside the EU, internal intervention price which protects the sales price of agricultural products, production quotas which prevent overproduction of wine.
- Single Market regulations and restrictions. Including food safety standards.
- Freedom of Movement. This includes trade inside Europe and immigrant seasonal workers for harvest period.
- Customs union regulations; taxes on imports (glass bottles and yeast from France, corks from Portugal, viticultural products from Germany, viticultural machines from Italy) and exports (the finalised products).

- International Trade deals. Since all trade deals are negotiated through the EU for all member states, if the UK were to leave it may need to renegotiate it's trade deals individually with each country or trade under WTO tariffs.

This paper was begun in January of 2019, at a point of peak uncertainty about the UK's future, and it is inevitable that in the course of writing this certain events will have taken place which we will be unable to effectively incorporate into our research. Therefore in order to avoid unhelpful speculation and unduly focusing on "Brexit", for the purposes of this project I will be operating on the assumption that on the 31st of October 2019 the UK's relationship with the EU will at least involve the 3 year transition period agreed upon by both the UK and EU. This transition period will preserve the status quo for at least the next three years, thus this paper is considering the status quo in all trade matters that might be affected by Brexit.

4.2.2 Climate Change:

As mentioned above, part of the incentive for being environmentally sustainable involves limiting a business' impact on climate change, primarily through working towards a "Carbon Neutral Footprint" or "Carbon Negative Footprint".

Scientists recommend that governments attempt to limit the increase in global average temperatures by 1.5°C, but recent projections and models indicate that an increase of 2°C or greater is far more likely (IPCC, 2018). The difference between the effects of an increase average temperature of 1.5°C and an increase average temperature of 2°C are stark, affecting everything from the annual number/intensity of heatwaves to the reduction of available freshwater in Mediterranean climates.

Similar to "Brexit", climate change has complex and unknowable ramifications for wine production in cooler climates. In order to keep this paper objective and simple I will be prioritising how to mitigate the effects of climate change over the effect climate change might have on future production. I am also assuming an increase in global average temperature of 2°C and some of the theoretical consequences that might have in a cool climate, such as the intense heatwaves and more frequent heavy rainfall.

4.2.3 Company choice and fashion

This report reflects the overarching choices of viticultural practices, and is designed to serve as a recommendation for viticulturists and companies alike, which challenges the assumed status quo of agriculture. However, in an effort to appeal to a wider audience for British agriculture this report will endeavour to focus on large choices which can be adapted to every vineyard in southeastern UK. As such I will not be putting huge emphasis upon choices such as Cultivar or Rootstock. Though this is a paper aimed at viticulture, I think that the choice of cultivar is such an important choice for the whole company, everyone from the marketing to enology will have a preference, and often some form of compromise will need to be made to reach a consensus. The choice of Rootstock again is prescriptive to the soil conditions and graft union with the chosen cultivar, and again is a more difficult choice to be made than is possible to prescribe in a literature review paper for the southeast of the UK.

5. References

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6. Appendices

Appendix 1: Climate data from East Malling weather station, growing

Date	2015					Huglin Index Calculator
	Daily Maximum Temperature (0900-0900) (°C)	Daily Minimum Temperature (0900-0900) (°C)	Daily Mean Temperature (0900-0900) (°C)	Daily Total Rainfall (0900-0900) (mm)	Daily Total Sunshine (0100-2400) (hrs)	
Apr 1	11.40	4.60	8.00	2.40	7.00	N/A
Apr 2	11.20	5.70	8.45	0.40	4.70	N/A
Apr 3	11.50	6.10	8.80	1.60	0.10	N/A
Apr 4	8.60	7.20	7.90	0.20	2.00	N/A
Apr 5	11.10	4.40	7.75	0.00	5.20	N/A
Apr 6	14.30	-0.80	6.75	0.00	5.10	N/A
Apr 7	16.50	0.00	8.25	0.00	9.20	N/A
Apr 8	15.60	4.60	10.10	0.00	5.90	3.02
Apr 9	15.50	4.30	9.90	0.00	8.30	5.88
Apr 10	19.70	1.60	10.65	0.00	5.60	11.37
Apr 11	13.70	7.80	10.75	1.20	7.30	13.73
Apr 12	15.70	0.70	8.20	0.00	12.50	15.79
Apr 13	15.50	7.40	11.45	0.00	4.70	19.48
Apr 14	21.70	3.20	12.45	0.00	13.60	26.98
Apr 15	24.20	5.20	14.70	0.00	13.20	36.99
Apr 16	14.90	7.60	11.25	0.00	4.80	40.25
Apr 17	12.60	8.20	10.40	0.00	7.60	41.84
Apr 18	12.60	5.20	8.90	0.00	11.90	42.64
Apr 19	11.60	4.50	8.05	0.00	4.70	42.45
Apr 20	16.70	2.80	9.75	0.00	13.60	45.87
Apr 21	16.00	4.70	10.35	0.00	14.10	49.24
Apr 22	12.90	5.30	9.10	0.00	6.20	50.30
Apr 23	15.10	7.70	11.40	0.00	9.20	53.74
Apr 24	18.40	1.70	10.05	1.00	7.90	58.22
Apr 25	17.30	10.10	13.70	3.20	3.20	64.05
Apr 26	9.40	8.20	8.80	0.00	0.10	63.10

	2015					
Apr 27	13.00	0.90	6.95	0.00	7.20	63.07
Apr 28	13.20	3.10	8.15	0.00	10.70	63.79
Apr 29	12.20	4.80	8.50	7.00	3.20	64.16
Apr 30	14.80	2.80	8.80	0.00	9.10	66.06
May 1	11.10	6.00	8.55	0.00	2.90	65.88
May 2	13.50	6.50	10.00	4.00	0.70	67.73
May 3	17.20	9.30	13.25	0.00	3.50	73.27
May 4	17.50	10.60	14.05	13.80	5.50	79.39
May 5	15.10	12.10	13.60	2.00	5.90	84.01
May 6	13.80	8.30	11.05	0.60	4.90	86.58
May 7	16.10	7.80	11.95	0.00	7.30	90.84
May 8	17.10	7.10	12.10	1.60	2.40	95.72
May 9	18.20	11.10	14.65	0.00	6.70	102.53
May 10	17.50	6.00	11.75	0.00	8.60	107.43
May 11	20.90	8.90	14.90	0.00	9.00	115.81
May 12	17.60	8.60	13.10	0.00	8.10	121.48
May 13	18.30	3.20	10.75	0.00	11.30	126.27
May 14	10.90	4.80	7.85	16.40	1.10	125.61
May 15	15.20	7.60	11.40	0.00	3.30	129.11
May 16	18.70	9.80	14.25	0.00	9.10	135.97
May 17	17.10	4.60	10.85	0.00	9.50	140.19
May 18	15.50	7.90	11.70	2.20	4.50	144.00
May 19	14.30	6.70	10.50	2.60	8.30	146.55
May 20	15.70	5.10	10.40	0.40	9.00	149.78
May 21	18.80	2.50	10.65	0.00	11.40	154.79
May 22	19.80	6.40	13.10	0.00	7.10	161.62
May 23	16.30	13.40	14.85	0.00	0.60	167.53
May 24	19.30	7.30	13.30	0.00	4.30	174.21
May 25	15.60	9.50	12.55	0.00	3.10	178.53
May 26	18.80	8.40	13.60	0.00	6.30	185.10
May 27	19.30	6.10	12.70	0.00	11.60	191.46
May 28	17.40	10.20	13.80	0.00	10.20	197.40
May 29	13.40	8.60	11.00	7.00	4.50	199.73
May 30	16.60	4.80	10.70	2.80	8.00	203.60

	2015					
May 31	15.10	9.90	12.50	0.20	1.80	207.63
Jun 1	14.90	6.60	10.75	1.80	3.70	210.62
Jun 2	16.60	10.10	13.35	0.00	3.40	215.90
Jun 3	19.40	10.30	14.85	0.00	9.10	223.45
Jun 4	21.60	5.70	13.65	11.20	15.90	231.53
Jun 5	25.20	10.60	17.90	0.00	10.90	243.77
Jun 6	18.90	7.40	13.15	0.00	11.80	250.16
Jun 7	19.30	5.50	12.40	0.00	12.90	256.36
Jun 8	17.70	5.40	11.55	0.00	11.10	261.26
Jun 9	15.10	7.40	11.25	0.00	4.00	264.63
Jun 10	18.30	9.30	13.80	0.00	6.70	271.04
Jun 11	20.90	11.60	16.25	0.00	15.40	280.13
Jun 12	23.00	12.40	17.70	7.40	4.40	291.10
Jun 13	19.90	14.00	16.95	0.00	2.90	300.03
Jun 14	16.70	9.80	13.25	0.80	0.80	305.31
Jun 15	17.00	10.80	13.90	0.00	8.10	311.08
Jun 16	20.80	5.00	12.90	0.00	8.50	318.34
Jun 17	24.50	9.40	16.95	0.60	11.50	329.71
Jun 18	21.00	14.20	17.60	0.00	12.60	339.57
Jun 19	20.10	11.90	16.00	0.00	9.50	348.10
Jun 20	18.40	10.30	14.35	3.00	4.00	354.86
Jun 21	20.10	13.10	16.60	5.00	4.10	363.71
Jun 22	17.70	10.30	14.00	0.20	2.00	369.91
Jun 23	19.00	11.10	15.05	0.00	3.90	377.36
Jun 24	21.70	8.40	15.05	0.00	9.70	386.24
Jun 25	24.10	9.50	16.80	0.00	10.90	397.31
Jun 26	24.80	9.60	17.20	0.00	6.80	408.97
Jun 27	23.90	11.80	17.85	0.00	12.40	420.50
Jun 28	21.60	13.80	17.70	0.00	4.50	430.73
Jun 29	24.40	11.70	18.05	0.00	14.20	442.63
Jun 30	27.80	9.00	18.40	0.00	15.70	456.52
Jul 1	33.50	16.80	25.15	0.00	8.50	477.00
Jul 2	23.60	15.40	19.50	0.40	5.10	489.24
Jul 3	24.10	12.20	18.15	5.00	12.90	501.04

	2015					
Jul 4	25.20	16.90	21.05	3.40	11.20	514.95
Jul 5	21.30	12.10	16.70	2.00	5.90	524.49
Jul 6	22.00	10.80	16.40	0.00	12.40	534.24
Jul 7	22.30	11.40	16.85	1.00	6.50	544.39
Jul 8	21.00	13.10	17.05	0.00	3.40	553.96
Jul 9	22.00	9.50	15.75	0.00	14.10	563.36
Jul 10	23.80	8.90	16.35	0.00	13.40	574.04
Jul 11	24.60	12.10	18.35	0.20	13.10	586.21
Jul 12	19.00	14.30	16.65	0.60	0.50	594.50
Jul 13	19.90	16.10	18.00	0.60	0.40	603.99
Jul 14	21.30	16.10	18.70	0.60	0.20	614.59
Jul 15	23.90	16.70	20.30	0.00	2.70	627.41
Jul 16	23.80	13.90	18.85	0.00	2.30	639.42
Jul 17	22.90	14.30	18.60	0.00	6.20	650.81
Jul 18	22.60	11.80	17.20	0.80	10.70	661.31
Jul 19	23.90	13.30	18.60	0.00	8.30	673.23
Jul 20	21.50	12.40	16.95	0.40	0.30	683.01
Jul 21	23.50	12.60	18.05	0.00	14.20	694.43
Jul 22	22.20	13.30	17.75	0.00	4.00	705.01
Jul 23	21.30	9.20	15.25	0.00	8.90	713.78
Jul 24	16.70	12.90	14.80	23.00	0.10	719.87
Jul 25	19.80	10.80	15.30	0.60	5.10	727.88
Jul 26	17.00	10.60	13.80	6.60	0.60	733.60
Jul 27	20.40	12.90	16.65	0.20	1.50	742.64
Jul 28	19.50	13.10	16.30	0.00	6.20	751.01
Jul 29	19.20	9.30	14.25	1.40	7.70	758.14
Jul 30	19.10	10.80	14.95	0.00	5.50	765.59
Jul 31	20.60	5.50	13.05	0.00	9.70	772.82
Aug 1	21.70	5.90	13.80	0.00	12.30	781.03
Aug 2	23.60	9.00	16.30	0.00	12.40	791.58
Aug 3	23.20	12.40	17.80	0.00	5.60	802.71
Aug 4	20.00	12.80	16.40	0.00	7.90	811.40
Aug 5	22.10	13.20	17.65	0.00	3.90	821.87
Aug 6	21.00	11.10	16.05	0.00	4.90	830.91

			2015			
Aug 7	24.20	8.00	16.10	0.00	9.70	841.67
Aug 8	24.90	10.90	17.90	0.00	7.50	853.75
Aug 9	25.60	8.50	17.05	0.00	14.20	865.76
Aug 10	23.90	15.30	19.60	0.80	3.70	878.21
Aug 11	20.50	13.90	17.20	1.20	0.30	887.59
Aug 12	20.70	14.90	17.80	1.40	2.90	897.40
Aug 13	20.10	16.80	18.45	13.60	2.00	907.23
Aug 14	22.10	17.10	19.60	1.60	7.00	918.73
Aug 15	20.30	13.90	17.10	0.00	6.10	927.95
Aug 16	18.30	7.80	13.05	0.00	2.30	933.97
Aug 17	20.00	8.20	14.10	0.00	7.00	941.44
Aug 18	18.10	13.10	15.60	0.00	0.00	948.70
Aug 19	20.80	11.40	16.10	4.00	6.80	957.66
Aug 20	21.70	14.10	17.90	0.40	0.70	968.05
Aug 21	25.20	17.20	21.20	0.00	6.10	982.04
Aug 22	27.90	12.30	20.10	0.00	12.40	996.88
Aug 23	20.40	18.00	19.20	9.00	6.50	1007.27
Aug 24	17.30	10.60	13.95	13.40	0.20	1013.23
Aug 25	18.10	10.70	14.40	6.40	4.10	1019.85
Aug 26	19.30	13.30	16.30	5.20	1.60	1028.12
Aug 27	17.50	12.90	15.20	0.20	2.10	1034.85
Aug 28	19.70	8.50	14.10	0.00	8.00	1042.17
Aug 29	20.70	11.70	16.20	3.00	3.10	1051.12
Aug 30	19.50	15.40	17.45	7.00	0.30	1060.11
Aug 31	15.10	14.30	14.70	3.80	0.00	1065.30
Sep 1	17.80	12.20	15.00	3.60	1.50	1072.08
Sep 2	17.40	6.80	12.10	0.00	6.40	1077.12
Sep 3	15.60	8.30	11.95	0.20	3.20	1081.12
Sep 4	14.80	8.10	11.45	0.00	1.00	1084.43
Sep 5	15.30	7.10	11.20	0.00	0.50	1087.88
Sep 6	17.90	4.40	11.15	0.00	10.00	1092.67
Sep 7	16.60	6.50	11.55	0.00	6.40	1096.99
Sep 8	15.30	6.80	11.05	0.00	1.10	1100.36
Sep 9	18.30	12.20	15.25	0.00	4.00	1107.54

	2015					
Sep 10	19.30	7.50	13.40	0.00	12.20	1114.27
Sep 11	20.20	5.90	13.05	1.00	9.40	1121.29
Sep 12	19.20	13.80	16.50	0.00	6.00	1129.62
Sep 13	16.00	7.20	11.60	4.40	0.50	1133.64
Sep 14	16.80	6.70	11.75	7.00	5.10	1138.18
Sep 15	17.30	8.40	12.85	4.00	1.90	1143.55
Sep 16	15.30	8.80	12.05	18.80	0.10	1147.45
Sep 17	16.90	10.10	13.50	4.60	6.10	1152.96
Sep 18	17.30	9.30	13.30	2.00	3.30	1158.58
Sep 19	17.60	9.60	13.60	0.00	6.60	1164.52
Sep 20	18.70	5.10	11.90	0.00	10.60	1170.13
Sep 21	15.50	8.30	11.90	17.00	1.10	1174.06
Sep 22	12.60	6.50	9.55	2.20	0.50	1175.20
Sep 23	18.00	7.70	12.85	1.00	6.40	1180.95
Sep 24	17.30	12.10	14.70	0.00	3.20	1187.31
Sep 25	16.20	6.20	11.20	0.00	6.80	1191.23
Sep 26	16.20	3.00	9.60	0.00	9.40	1194.30
Sep 27	16.50	6.30	11.40	0.00	9.70	1198.49
Sep 28	16.50	5.00	10.75	0.00	10.10	1202.33
Sep 29	16.70	5.90	11.30	0.00	10.20	1206.57
Sep 30	16.40	8.20	12.30	0.00	10.90	1211.18

Appendix 2: Climate data from East Malling weather station, growing

	2016					
Date	Daily Maximum Temperature (0900-0900) (°C)	Daily Minimum Temperature (0900-0900) (°C)	Daily Mean Temperature (0900-0900) (°C)	Daily Total Rainfall (0900-0900) (mm)	Daily Total Sunshine (0100-2400) (hrs)	Huglin Index Calculator
Apr 1	12.40	-1.50	5.45	0.00	8.80	N/A
Apr 2	13.70	2.60	8.15	1.60	7.20	N/A
Apr 3	16.20	6.70	11.45	7.20	7.70	4.05
Apr 4	13.20	7.70	10.45	0.00	2.40	5.99

	2016					
Apr 5	14.30	3.80	9.05	0.20	3.60	7.76
Apr 6	13.20	4.90	9.05	1.60	5.00	8.96
Apr 7	10.10	3.60	6.85	4.00	2.90	7.34
Apr 8	13.00	2.10	7.55	1.00	2.80	7.63
Apr 9	10.20	5.40	7.80	0.40	1.20	6.57
Apr 10	12.70	-1.60	5.55	0.00	10.40	5.64
Apr 11	14.20	8.00	11.10	3.00	1.90	8.45
Apr 12	16.80	7.80	12.30	0.00	10.30	13.28
Apr 13	17.20	1.70	9.45	2.60	5.50	16.80
Apr 14	16.80	3.50	10.15	6.00	6.60	20.48
Apr 15	13.50	8.50	11.00	7.20	1.10	22.87
Apr 16	8.20	5.00	6.60	0.00	2.70	20.11
Apr 17	11.50	0.40	5.95	0.00	11.30	18.76
Apr 18	12.30	-0.10	6.10	0.00	5.10	17.91
Apr 19	14.80	8.50	11.65	0.00	8.60	21.33
Apr 20	12.30	0.90	6.60	0.00	13.30	20.75
Apr 21	14.10	6.50	10.30	0.00	6.60	23.08
Apr 22	10.80	8.40	9.60	2.20	0.10	23.29
Apr 23	10.40	4.00	7.20	0.40	6.40	22.02
Apr 24	10.00	2.80	6.40	0.20	1.40	20.11
Apr 25	11.70	3.90	7.80	1.80	0.80	19.85
Apr 26	9.00	1.70	5.35	0.00	6.80	16.85
Apr 27	11.20	1.80	6.50	0.00	7.60	15.64
Apr 28	11.70	0.00	5.85	0.00	9.90	14.34
Apr 29	12.00	5.70	8.85	0.40	7.30	14.79
Apr 30	13.60	1.30	7.45	0.00	8.40	15.34
May 1	15.20	-1.10	7.05	0.00	12.40	16.54
May 2	14.70	8.60	11.65	0.20	1.00	19.90
May 3	16.40	5.30	10.85	0.00	11.90	23.74
May 4	16.90	2.10	9.50	0.00	14.60	27.14
May 5	19.20	2.20	10.70	0.00	14.20	32.38
May 6	22.80	5.10	13.95	0.00	11.40	41.26
May 7	23.20	9.00	16.10	0.00	6.50	51.49
May 8	25.30	7.40	16.35	0.00	13.30	62.96

	2016					
May 9	23.40	11.10	17.25	4.60	5.80	73.91
May 10	18.70	14.50	16.60	9.80	0.10	82.02
May 11	20.20	13.70	16.95	3.60	2.90	91.11
May 12	20.00	12.60	16.30	0.00	10.70	99.75
May 13	20.50	11.00	15.75	0.00	7.40	108.36
May 14	12.60	7.00	9.80	0.00	4.10	109.63
May 15	17.90	1.10	9.50	0.00	8.90	113.55
May 16	17.70	8.30	13.00	0.00	6.70	119.22
May 17	18.20	4.50	11.35	0.00	7.50	124.29
May 18	14.20	10.40	12.30	8.00	0.70	127.73
May 19	17.80	10.50	14.15	0.00	4.20	134.06
May 20	19.00	11.90	15.45	0.00	5.60	141.72
May 21	17.80	11.10	14.45	0.80	0.80	148.21
May 22	18.20	11.90	15.05	7.20	2.30	155.24
May 23	18.50	10.70	14.60	0.00	3.80	162.18
May 24	16.10	7.30	11.70	0.00	11.50	166.31
May 25	14.40	8.80	11.60	0.00	0.10	169.49
May 26	18.40	3.10	10.75	0.00	10.00	174.34
May 27	18.80	10.50	14.65	0.40	8.50	181.47
May 28	18.20	11.50	14.85	0.00	8.10	188.39
May 29	20.40	9.30	14.85	0.00	7.40	196.47
May 30	15.50	11.60	13.55	37.40	0.10	201.27
May 31	12.70	10.50	11.60	3.00	0.00	203.55
Jun 1	12.50	10.90	11.70	7.00	0.00	205.77
Jun 2	13.20	10.00	11.60	0.00	0.00	208.32
Jun 3	13.70	9.20	11.45	0.00	0.70	211.05
Jun 4	18.40	10.10	14.25	0.00	10.10	217.75
Jun 5	20.80	11.60	16.20	0.00	10.00	226.76
Jun 6	20.00	10.30	15.15	0.00	11.90	234.79
Jun 7	22.20	10.20	16.20	4.60	6.90	244.54
Jun 8	24.80	11.70	18.25	0.00	7.40	256.76
Jun 9	19.50	12.00	15.75	0.00	6.30	264.84
Jun 10	22.00	9.00	15.50	0.00	5.70	274.12
Jun 11	23.10	12.20	17.65	0.40	1.20	285.11

	2016					
Jun 12	19.10	14.00	16.55	0.60	2.70	293.41
Jun 13	18.80	12.70	15.75	1.60	2.30	301.12
Jun 14	18.20	13.50	15.85	0.20	4.30	308.57
Jun 15	19.00	11.60	15.30	0.20	5.70	316.15
Jun 16	18.60	9.50	14.05	5.40	3.00	322.85
Jun 17	16.10	11.30	13.70	17.80	0.90	328.04
Jun 18	18.30	10.70	14.50	0.00	0.40	334.83
Jun 19	20.30	11.00	15.65	4.40	6.70	343.28
Jun 20	22.00	14.50	18.25	4.60	4.30	354.01
Jun 21	21.80	15.10	18.45	0.20	6.90	364.75
Jun 22	21.50	12.80	17.15	21.20	2.30	374.63
Jun 23	23.20	16.50	19.85	11.60	0.90	386.85
Jun 24	21.60	11.80	16.70	0.00	13.10	396.55
Jun 25	19.30	10.00	14.65	5.80	6.60	403.94
Jun 26	20.50	10.50	15.50	0.80	4.70	412.42
Jun 27	21.60	13.70	17.65	0.00	5.00	422.62
Jun 28	20.20	10.00	15.10	3.00	7.60	430.73
Jun 29	17.70	10.70	14.20	4.00	4.20	437.04
Jun 30	19.40	13.10	16.25	0.40	3.50	445.33
Jul 1	18.20	14.80	16.50	1.40	3.40	453.12
Jul 2	18.30	9.50	13.90	1.60	12.90	459.59
Jul 3	20.10	9.10	14.60	0.00	13.70	467.38
Jul 4	21.30	9.60	15.45	0.00	4.30	476.26
Jul 5	21.40	14.80	18.10	0.00	5.50	486.59
Jul 6	21.80	9.40	15.60	0.00	9.40	495.82
Jul 7	20.70	12.60	16.65	0.00	3.50	505.01
Jul 8	23.00	13.70	18.35	0.00	3.10	516.33
Jul 9	22.30	13.20	17.75	0.00	5.80	526.95
Jul 10	20.70	15.30	18.00	0.40	3.70	536.86
Jul 11	20.90	15.00	17.95	0.60	4.50	546.85
Jul 12	18.70	13.10	15.90	7.40	5.10	554.59
Jul 13	18.20	11.30	14.75	1.20	2.10	561.46
Jul 14	20.90	10.70	15.80	0.00	8.70	570.31
Jul 15	21.70	9.40	15.55	0.00	8.50	579.45

	2016					
Jul 16	26.50	16.00	21.25	0.00	6.20	594.16
Jul 17	26.60	18.10	22.35	0.00	6.70	609.50
Jul 18	28.10	14.10	21.10	0.00	14.50	624.98
Jul 19	30.70	12.50	21.60	0.00	15.70	642.10
Jul 20	28.90	18.20	23.55	0.00	12.30	659.29
Jul 21	23.80	13.30	18.55	0.00	3.50	671.14
Jul 22	24.50	15.00	19.75	0.00	4.90	683.99
Jul 23	26.40	12.10	19.25	0.00	13.60	697.59
Jul 24	23.70	11.50	17.60	0.00	10.50	708.88
Jul 25	23.70	15.00	19.35	0.00	8.40	721.09
Jul 26	22.10	12.00	17.05	0.40	7.70	731.24
Jul 27	23.30	15.70	19.50	0.00	3.80	743.33
Jul 28	23.00	11.80	17.40	0.40	5.10	754.14
Jul 29	22.90	16.40	19.65	0.00	4.30	766.09
Jul 30	20.20	12.80	16.50	0.60	0.90	774.94
Jul 31	22.20	12.10	17.15	0.00	6.70	785.20
Aug 1	18.30	11.40	14.85	15.40	0.70	792.16
Aug 2	20.20	13.50	16.85	2.40	0.30	801.20
Aug 3	22.00	17.80	19.90	0.00	5.60	812.81
Aug 4	22.10	14.40	18.25	0.00	6.80	823.59
Aug 5	23.80	11.60	17.70	0.00	10.50	834.99
Aug 6	24.40	12.10	18.25	0.00	13.40	846.99
Aug 7	25.30	15.10	20.20	0.00	5.70	860.51
Aug 8	21.30	13.70	17.50	0.00	6.10	870.47
Aug 9	20.10	10.40	15.25	0.00	8.50	878.61
Aug 10	20.00	8.80	14.40	0.00	6.80	886.24
Aug 11	22.60	12.10	17.35	0.00	4.10	896.81
Aug 12	25.50	13.40	19.45	0.00	14.10	910.04
Aug 13	23.40	13.30	18.35	0.00	8.30	921.56
Aug 14	22.70	12.50	17.60	0.00	6.90	932.32
Aug 15	21.70	8.10	14.90	0.00	12.60	941.12
Aug 16	22.10	8.80	15.45	0.00	9.20	950.42
Aug 17	23.50	10.90	17.20	0.00	13.10	961.39
Aug 18	23.50	12.40	17.95	0.00	3.40	972.76

	2016					
Aug 19	20.40	13.40	16.90	4.00	0.50	981.93
Aug 20	20.00	13.80	16.90	2.60	6.70	990.89
Aug 21	21.80	14.70	18.25	0.00	3.50	1001.51
Aug 22	23.90	16.20	20.05	0.00	8.40	1014.21
Aug 23	28.40	11.00	19.70	0.00	11.00	1029.10
Aug 24	32.10	14.70	23.40	0.20	10.10	1047.92
Aug 25	29.20	18.30	23.75	1.40	9.60	1065.38
Aug 26	27.60	18.30	22.95	0.00	11.10	1081.57
Aug 27	26.40	13.50	19.95	0.00	8.30	1095.54
Aug 28	21.70	16.30	19.00	0.80	4.30	1106.51
Aug 29	23.60	15.10	19.35	0.00	6.50	1118.67
Aug 30	25.50	10.70	18.10	0.00	11.70	1131.18
Aug 31	23.60	9.50	16.55	0.00	9.80	1141.86
Sep 1	23.60	10.80	17.20	0.00	9.90	1152.88
Sep 2	20.50	11.50	16.00	0.20	1.70	1161.63
Sep 3	21.30	10.30	15.80	1.80	5.00	1170.69
Sep 4	21.00	16.00	18.50	3.40	3.00	1181.03
Sep 5	21.60	14.30	17.95	0.40	0.10	1191.39
Sep 6	24.60	15.40	20.00	0.00	0.70	1204.43
Sep 7	27.30	17.80	22.55	0.00	8.80	1220.25
Sep 8	23.70	11.00	17.35	0.40	11.00	1231.40
Sep 9	22.70	11.20	16.95	0.00	4.20	1241.82
Sep 10	21.60	15.70	18.65	1.20	0.90	1252.55
Sep 11	21.70	7.50	14.60	0.00	12.40	1261.19
Sep 12	26.40	9.30	17.85	0.00	8.60	1274.04
Sep 13	31.30	13.70	22.50	0.00	10.00	1291.95
Sep 14	26.20	15.90	21.05	0.00	9.60	1306.40
Sep 15	27.60	13.50	20.55	0.40	9.70	1321.32
Sep 16	17.50	17.00	17.25	2.40	0.70	1329.13
Sep 17	16.10	13.00	14.55	0.20	0.00	1334.78
Sep 18	19.30	13.80	16.55	0.00	0.30	1343.18
Sep 19	20.90	11.50	16.20	0.00	1.40	1352.24
Sep 20	19.20	14.20	16.70	0.00	1.10	1360.67
Sep 21	22.00	10.60	16.30	0.00	8.10	1370.37

	2016					
Sep 22	20.60	10.60	15.60	0.00	3.10	1378.95
Sep 23	19.60	6.20	12.90	0.00	10.70	1385.58
Sep 24	23.10	6.30	14.70	0.00	7.30	1395.01
Sep 25	20.60	15.80	18.20	0.00	4.50	1404.98
Sep 26	18.20	6.80	12.50	0.20	2.00	1410.65
Sep 27	19.70	6.40	13.05	0.00	1.70	1417.41
Sep 28	22.90	11.90	17.40	0.20	6.70	1428.16
Sep 29	18.80	15.40	17.10	0.60	2.70	1436.59
Sep 30	18.40	9.30	13.85	3.20	8.20	1443.08

Appendix 3: Climate data from East Malling weather station, growing

	2017					
Date	Daily Maximum Temperature (0900-0900) (°C)	Daily Minimum Temperature (0900-0900) (°C)	Daily Mean Temperature (0900-0900) (°C)	Daily Total Rainfall (0900-0900) (mm)	Daily Total Sunshine (0100-2400) (hrs)	Huglin Index Calculation
Apr 1	15.70	7.10	11.40	1.40	5.00	3.76
Apr 2	16.30	5.00	10.65	0.00	8.40	7.45
Apr 3	16.50	3.10	9.80	0.40	7.00	10.79
Apr 4	15.10	6.30	10.70	0.20	0.70	13.86
Apr 5	14.40	6.00	10.20	0.00	10.40	16.30
Apr 6	17.10	3.40	10.25	0.00	13.00	20.19
Apr 7	17.70	2.60	10.15	0.00	13.10	24.35
Apr 8	18.80	4.20	11.50	0.00	10.20	29.81
Apr 9	23.40	4.20	13.80	0.00	13.20	38.93
Apr 10	14.50	8.70	11.60	0.00	7.70	42.16
Apr 11	15.50	3.80	9.65	0.00	11.30	44.89
Apr 12	16.80	3.70	10.25	0.00	4.60	48.63
Apr 13	14.40	5.70	10.05	0.00	5.00	50.99
Apr 14	14.90	3.80	9.35	0.00	3.50	53.24
Apr 15	14.40	9.90	12.15	0.00	4.10	56.71
Apr 16	14.40	5.80	10.10	0.00	4.20	59.10

	2017					
Apr 17	12.10	7.60	9.85	0.20	2.40	60.13
Apr 18	12.50	0.20	6.35	0.00	7.60	59.52
Apr 19	11.80	0.00	5.90	0.00	11.90	58.30
Apr 20	14.80	-1.10	6.85	0.00	3.70	59.17
Apr 21	16.00	3.20	9.60	0.20	0.40	62.14
Apr 22	14.20	8.60	11.40	0.80	2.30	65.11
Apr 23	14.30	7.10	10.70	0.00	3.80	67.76
Apr 24	14.60	3.40	9.00	0.20	3.00	69.67
Apr 25	10.60	0.20	5.40	0.00	9.50	67.55
Apr 26	9.30	2.20	5.75	1.40	3.30	64.93
Apr 27	11.10	-0.80	5.15	0.60	5.10	62.94
Apr 28	13.30	5.60	9.45	0.00	3.50	64.40
Apr 29	15.70	3.90	9.80	0.00	8.90	67.31
Apr 30	17.30	9.80	13.55	3.40	4.50	73.06
May 1	14.30	7.60	10.95	0.80	3.40	75.84
May 2	16.70	2.50	9.60	1.00	4.60	79.18
May 3	11.00	6.80	8.90	3.00	0.10	79.13
May 4	13.00	8.40	10.70	0.00	1.30	81.09
May 5	12.80	9.40	11.10	0.00	1.70	83.16
May 6	14.30	9.20	11.75	0.00	5.00	86.36
May 7	15.30	5.80	10.55	0.00	3.10	89.46
May 8	12.30	7.30	9.80	0.00	2.10	90.58
May 9	11.90	5.90	8.90	0.00	0.80	91.00
May 10	15.70	-0.90	7.40	0.00	12.90	92.64
May 11	21.90	3.70	12.80	2.80	7.20	100.44
May 12	17.60	11.90	14.75	1.20	4.30	106.98
May 13	17.70	10.20	13.95	1.60	6.50	113.16
May 14	19.00	7.00	13.00	0.60	9.00	119.52
May 15	19.80	5.50	12.65	0.00	0.30	126.11
May 16	23.80	12.50	18.15	14.40	6.10	137.75
May 17	20.50	15.00	17.75	12.60	1.10	147.42
May 18	16.50	10.40	13.45	16.80	3.00	152.69
May 19	14.70	9.40	12.05	0.00	3.50	156.27
May 20	16.80	5.30	11.05	0.00	11.20	160.43

	2017					
May 21	19.10	6.40	12.75	0.00	12.60	166.71
May 22	23.20	6.40	14.80	0.00	9.80	176.25
May 23	20.80	11.60	16.20	0.00	6.70	185.26
May 24	24.60	10.20	17.40	0.00	14.10	196.92
May 25	23.20	10.30	16.75	0.00	14.80	207.50
May 26	25.40	10.00	17.70	0.40	15.90	219.74
May 27	22.90	10.50	16.70	0.00	11.40	230.13
May 28	23.90	8.60	16.25	6.60	10.20	240.81
May 29	23.10	12.00	17.55	0.00	4.50	251.75
May 30	20.00	14.70	17.35	0.00	3.50	260.95
May 31	21.90	10.40	16.15	0.00	3.00	270.51
Jun 1	23.80	9.20	16.50	0.00	10.40	281.27
Jun 2	25.30	8.80	17.05	2.60	7.10	293.12
Jun 3	20.80	14.50	17.65	0.00	9.40	302.90
Jun 4	18.90	9.80	14.35	0.00	11.00	309.92
Jun 5	18.20	9.40	13.80	15.40	7.00	316.28
Jun 6	16.30	9.50	12.90	4.20	4.40	321.15
Jun 7	19.40	9.70	14.55	0.00	8.00	328.55
Jun 8	18.90	13.10	16.00	8.20	2.50	336.44
Jun 9	20.00	12.50	16.25	1.00	7.00	345.06
Jun 10	21.80	12.20	17.00	0.00	12.80	355.02
Jun 11	21.90	12.10	17.00	0.00	9.30	365.04
Jun 12	19.20	10.40	14.80	0.00	5.70	372.46
Jun 13	23.00	8.50	15.75	0.00	9.50	382.40
Jun 14	24.60	8.30	16.45	0.00	15.20	393.55
Jun 15	24.30	12.30	18.30	0.00	13.30	405.53
Jun 16	23.10	11.60	17.35	0.00	10.90	416.37
Jun 17	28.00	13.80	20.90	0.00	14.00	431.69
Jun 18	29.70	14.60	22.15	0.00	14.60	448.57
Jun 19	28.20	13.80	21.00	0.00	14.00	464.04
Jun 20	27.60	12.90	20.25	0.00	13.60	478.80
Jun 21	31.40	14.90	23.15	0.00	13.40	497.11
Jun 22	24.80	17.30	21.05	0.60	6.50	510.81
Jun 23	23.20	12.60	17.90	0.00	12.20	522.00

	2017					
Jun 24	21.60	15.50	18.55	0.00	1.60	532.68
Jun 25	22.10	14.90	18.50	0.00	3.10	543.59
Jun 26	22.60	12.00	17.30	0.00	10.00	554.14
Jun 27	22.70	14.20	18.45	48.60	0.00	565.35
Jun 28	18.20	14.60	16.40	0.00	0.00	573.09
Jun 29	18.90	12.20	15.55	0.00	3.00	580.75
Jun 30	21.50	11.90	16.70	0.40	5.90	590.39
Jul 1	21.00	13.30	17.15	0.00	3.00	600.01
Jul 2	23.00	15.20	19.10	0.00	10.70	611.73
Jul 3	22.70	13.10	17.90	0.00	5.10	622.64
Jul 4	23.70	11.20	17.45	0.00	11.60	633.85
Jul 5	25.40	11.80	18.60	0.00	14.40	646.57
Jul 6	28.20	13.80	21.00	0.00	8.90	662.05
Jul 7	27.90	16.20	22.05	0.00	12.40	677.92
Jul 8	25.70	17.60	21.65	0.00	6.50	692.42
Jul 9	26.00	13.30	19.65	0.00	11.20	706.01
Jul 10	25.60	12.80	19.20	0.00	8.10	719.16
Jul 11	20.60	13.90	17.25	31.00	0.70	728.62
Jul 12	21.00	13.90	17.45	0.40	4.00	738.40
Jul 13	21.00	7.30	14.15	0.00	8.90	746.43
Jul 14	20.50	13.10	16.80	0.00	5.80	755.59
Jul 15	21.10	10.50	15.80	0.00	1.20	764.55
Jul 16	25.10	17.10	21.10	0.00	3.70	778.44
Jul 17	24.60	15.00	19.80	0.00	11.50	791.37
Jul 18	24.50	12.20	18.35	17.40	7.30	803.48
Jul 19	22.90	17.70	20.30	4.60	3.30	815.78
Jul 20	20.40	16.80	18.60	4.60	3.60	825.85
Jul 21	21.10	9.50	15.30	6.40	12.00	834.54
Jul 22	19.80	13.90	16.85	6.80	3.90	843.36
Jul 23	18.80	9.20	14.00	7.20	4.80	850.15
Jul 24	17.40	12.90	15.15	2.00	0.40	856.80
Jul 25	22.50	13.80	18.15	0.00	6.10	867.74
Jul 26	20.50	11.20	15.85	0.40	1.80	876.41
Jul 27	20.70	13.40	17.05	0.60	4.60	885.82

	2017					
Jul 28	19.90	13.30	16.60	1.00	0.50	894.56
Jul 29	20.50	15.90	18.20	5.60	3.70	904.47
Jul 30	20.60	15.80	18.20	0.00	6.60	914.44
Jul 31	21.40	12.00	16.70	0.00	10.20	924.03
Aug 1	22.60	8.70	15.65	0.00	11.40	933.70
Aug 2	18.40	13.30	15.85	9.80	0.10	941.25
Aug 3	20.40	14.90	17.65	0.00	4.60	950.82
Aug 4	21.90	14.50	18.20	0.60	9.70	961.47
Aug 5	20.60	13.70	17.15	4.40	7.10	970.88
Aug 6	21.10	7.70	14.40	0.00	12.40	979.10
Aug 7	19.90	10.30	15.10	0.00	4.70	987.05
Aug 8	21.60	10.90	16.25	0.00	3.00	996.51
Aug 9	17.90	11.00	14.45	27.20	1.70	1003.05
Aug 10	18.60	12.80	15.70	0.00	2.10	1010.63
Aug 11	21.10	8.20	14.65	0.20	8.60	1018.98
Aug 12	22.70	16.00	19.35	0.00	5.10	1030.66
Aug 13	22.30	13.20	17.75	0.00	11.10	1041.29
Aug 14	23.30	9.10	16.20	1.20	10.20	1051.63
Aug 15	24.00	12.50	18.25	0.00	7.80	1063.42
Aug 16	22.10	9.00	15.55	3.80	6.40	1072.77
Aug 17	22.60	13.90	18.25	0.40	6.30	1083.82
Aug 18	21.20	15.30	18.25	0.00	7.40	1094.13
Aug 19	20.50	12.90	16.70	0.00	7.00	1103.25
Aug 20	20.70	8.80	14.75	5.00	7.10	1111.44
Aug 21	20.00	13.20	16.60	0.00	0.20	1120.23
Aug 22	22.80	15.60	19.20	0.20	2.80	1131.89
Aug 23	23.50	13.80	18.65	0.00	4.00	1143.63
Aug 24	21.50	11.00	16.25	0.00	6.00	1153.04
Aug 25	24.10	8.80	16.45	0.00	10.70	1163.93
Aug 26	25.40	12.10	18.75	0.00	8.60	1176.73
Aug 27	25.60	12.10	18.85	0.00	9.90	1189.69
Aug 28	27.20	11.20	19.20	0.00	11.20	1203.68
Aug 29	27.30	14.00	20.65	0.40	7.00	1218.50
Aug 30	15.10	12.40	13.75	4.20	0.00	1223.19

	2017					
Aug 31	18.90	6.40	12.65	2.20	9.00	1229.31
Sep 1	20.60	7.20	13.90	6.60	8.70	1236.99
Sep 2	21.20	7.50	14.35	0.00	11.50	1245.24
Sep 3	18.50	7.60	13.05	1.20	2.80	1251.36
Sep 4	20.60	13.50	17.05	0.60	0.30	1260.71
Sep 5	20.00	16.10	18.05	0.60	0.60	1270.28
Sep 6	18.50	10.90	14.70	0.00	5.40	1277.27
Sep 7	18.70	11.00	14.85	0.20	4.20	1284.46
Sep 8	17.10	14.40	15.75	5.40	0.60	1291.27
Sep 9	18.70	9.20	13.95	0.20	8.10	1297.97
Sep 10	17.10	6.80	11.95	1.60	2.30	1302.77
Sep 11	18.90	11.00	14.95	2.00	5.10	1310.11
Sep 12	18.40	8.90	13.65	2.80	8.40	1316.49
Sep 13	18.50	12.80	15.65	0.00	8.20	1323.99
Sep 14	17.90	7.60	12.75	0.00	5.10	1329.64
Sep 15	16.90	5.70	11.30	0.00	6.90	1333.98
Sep 16	15.70	5.40	10.55	0.00	2.10	1337.30
Sep 17	16.80	7.60	12.20	0.60	4.80	1342.07
Sep 18	16.90	7.90	12.40	1.40	2.60	1347.00
Sep 19	16.20	8.80	12.50	0.00	3.60	1351.61
Sep 20	17.00	5.60	11.30	0.00	3.10	1356.01
Sep 21	19.10	9.60	14.35	0.40	4.40	1363.13
Sep 22	18.30	5.50	11.90	0.00	9.90	1368.54
Sep 23	19.40	7.50	13.45	0.00	2.30	1375.35
Sep 24	21.00	7.20	14.10	1.40	8.90	1383.35
Sep 25	18.00	13.60	15.80	0.40	0.10	1390.67
Sep 26	20.10	12.80	16.45	0.00	3.80	1399.44
Sep 27	20.90	8.70	14.80	10.40	2.50	1407.76
Sep 28	20.00	14.40	17.20	2.60	5.60	1416.88
Sep 29	19.70	10.40	15.05	0.60	0.80	1424.69
Sep 30	17.60	9.40	13.50	1.80	3.20	1430.58

Appendix 4: Climate data from East Malling weather station, growing 2018

Date	Daily Maximum Temperature (0900-0900) (°C)	Daily Minimum Temperature (0900-0900) (°C)	Daily Mean Temperature (0900-0900) (°C)	Daily Total Rainfall (0900-0900) (mm)	Daily Total Sunshine (0100-2400) (hrs)	Huglin Index Calculator
Apr 1	8.60	3.70	6.15	9.00	0.30	N/A
Apr 2	12.80	4.40	8.60	8.00	1.30	N/A
Apr 3	13.80	8.60	11.20	0.40	0.40	2.65
Apr 4	12.50	6.50	9.50	0.00	3.10	3.71
Apr 5	12.00	4.90	8.45	0.00	8.70	3.95
Apr 6	16.20	4.50	10.35	0.00	8.90	7.42
Apr 7	17.60	5.20	11.40	6.40	3.70	12.19
Apr 8	13.50	8.00	10.75	2.20	0.10	14.44
Apr 9	9.30	8.50	8.90	6.60	0.00	13.49
Apr 10	12.90	7.40	10.15	5.00	1.10	15.11
Apr 11	10.70	8.00	9.35	0.00	0.00	15.13
Apr 12	9.50	7.30	8.40	2.00	0.00	14.02
Apr 13	12.30	6.40	9.35	0.00	0.60	14.89
Apr 14	17.10	3.40	10.25	0.00	10.10	18.79
Apr 15	15.20	7.90	11.55	1.40	1.70	22.37
Apr 16	14.90	8.10	11.50	0.00	7.70	25.76
Apr 17	18.70	6.60	12.65	0.00	8.10	31.77
Apr 18	22.60	6.80	14.70	0.00	13.90	40.94
Apr 19	27.10	7.40	17.25	0.00	13.60	53.85
Apr 20	26.00	7.10	16.55	0.00	12.10	65.80
Apr 21	23.60	7.80	15.70	0.40	13.30	76.03
Apr 22	22.50	9.60	16.05	0.00	11.70	85.86
Apr 23	15.60	6.40	11.00	0.00	8.40	89.36
Apr 24	17.30	9.80	13.55	0.00	1.90	95.11
Apr 25	15.40	7.40	11.40	0.80	7.60	98.71
Apr 26	14.20	5.50	9.85	1.00	9.30	100.86
Apr 27	13.20	5.10	9.15	10.20	0.60	102.10
Apr 28	9.80	8.40	9.10	0.00	0.20	101.52
Apr 29	7.80	6.60	7.20	24.20	0.00	98.87
Apr 30	9.70	4.60	7.15	15.00	0.10	97.20
May 1	13.80	1.70	7.75	0.00	11.70	98.02
May 2	13.70	6.30	10.00	5.40	3.60	99.98
May 3	15.90	0.30	8.10	0.00	7.50	102.10
May 4	19.40	6.40	12.90	0.00	12.10	108.62
May 5	18.80	3.30	11.05	0.00	14.90	113.84
May 6	21.90	5.50	13.70	0.00	14.70	122.11
May 7	24.10	6.30	15.20	0.00	15.00	132.34
May 8	25.50	6.40	15.95	0.00	12.90	143.71
May 9	20.50	7.10	13.80	0.60	8.00	151.29
May 10	17.20	9.90	13.55	0.00	6.30	156.99

2018						
May 11	17.00	3.10	10.05	0.00	7.10	160.72
May 12	15.10	8.60	11.85	11.00	2.00	164.41
May 13	17.30	8.00	12.65	0.00	5.70	169.68
May 14	18.40	6.80	12.60	0.00	10.00	175.51
May 15	20.90	9.70	15.30	0.00	14.20	184.10
May 16	15.10	10.60	12.85	0.00	4.70	188.31
May 17	15.30	6.00	10.65	0.00	9.90	191.46
May 18	17.00	2.30	9.65	0.00	13.40	194.99
May 19	18.50	3.00	10.75	0.00	15.10	199.89
May 20	18.50	5.70	12.10	0.00	9.50	205.51
May 21	20.70	7.30	14.00	0.20	6.20	213.30
May 22	22.80	11.20	17.00	0.20	9.20	223.79
May 23	18.40	10.00	14.20	4.00	6.30	230.47
May 24	18.30	11.40	14.85	0.00	0.30	237.44
May 25	21.30	13.10	17.20	0.40	2.00	247.25
May 26	22.20	12.80	17.50	12.20	11.40	257.69
May 27	26.40	14.50	20.45	0.20	10.80	271.92
May 28	24.20	11.90	18.05	0.80	12.30	283.71
May 29	16.90	13.60	15.25	13.00	0.30	290.15
May 30	22.10	12.70	17.40	0.00	3.70	300.48
May 31	20.20	14.10	17.15	0.20	0.70	309.68
Jun 1	22.30	15.20	18.75	0.00	5.50	320.84
Jun 2	23.60	14.40	19.00	0.00	8.00	332.81
Jun 3	25.30	10.60	17.95	0.00	13.10	345.14
Jun 4	16.80	13.20	15.00	0.00	0.20	351.39
Jun 5	16.30	12.10	14.20	0.00	4.70	356.96
Jun 6	20.00	9.70	14.85	0.20	9.00	364.83
Jun 7	20.00	11.60	15.80	0.00	6.40	373.20
Jun 8	21.10	10.50	15.80	0.00	11.90	382.16
Jun 9	20.20	12.90	16.55	0.00	5.60	391.03
Jun 10	19.00	13.50	16.25	0.00	5.50	399.12
Jun 11	20.70	11.40	16.05	0.00	9.60	407.99
Jun 12	16.50	12.70	14.60	0.80	1.10	413.88
Jun 13	21.20	5.50	13.35	0.20	10.10	421.59
Jun 14	23.00	12.60	17.80	0.40	4.70	432.61
Jun 15	23.10	9.70	16.40	0.00	10.50	442.95
Jun 16	19.00	12.40	15.70	0.20	2.80	450.74
Jun 17	19.10	11.50	15.30	0.00	2.30	458.37
Jun 18	24.40	14.00	19.20	0.00	9.00	470.88
Jun 19	24.00	16.20	20.10	0.00	5.70	483.65
Jun 20	23.90	14.30	19.10	0.00	7.50	495.84
Jun 21	19.90	11.40	15.65	0.00	13.10	504.08
Jun 22	21.50	6.50	14.00	0.00	16.00	512.30
Jun 23	23.80	6.30	15.05	0.00	10.20	522.29
Jun 24	22.70	9.10	15.90	0.00	15.60	532.15
Jun 25	26.90	9.60	18.25	0.00	16.30	545.48
Jun 26	24.60	9.90	17.25	0.00	16.10	557.06
Jun 27	21.80	12.40	17.10	0.00	14.60	567.07
Jun 28	24.60	13.60	19.10	0.00	8.40	579.63

			2018			
Jun 29	24.80	13.10	18.95	0.00	12.90	592.22
Jun 30	23.80	13.40	18.60	0.00	13.70	604.09
Jul 1	26.10	14.10	20.10	0.00	12.60	617.98
Jul 2	25.40	15.60	20.50	0.00	16.40	631.71
Jul 3	23.00	15.30	19.15	0.00	13.70	643.45
Jul 4	24.50	12.40	18.45	0.00	7.10	655.61
Jul 5	27.30	13.10	20.20	0.00	7.10	670.19
Jul 6	30.10	12.30	21.20	0.00	11.40	686.77
Jul 7	31.50	13.90	22.70	0.00	11.90	704.90
Jul 8	28.90	15.60	22.25	0.00	14.20	721.41
Jul 9	27.60	12.00	19.80	0.00	5.50	735.93
Jul 10	22.90	11.60	17.25	0.00	5.20	746.61
Jul 11	22.20	13.80	18.00	0.00	3.90	757.32
Jul 12	23.20	11.70	17.45	0.00	5.80	768.26
Jul 13	24.50	14.40	19.45	0.00	9.90	780.96
Jul 14	27.10	10.70	18.90	0.00	14.10	794.74
Jul 15	29.80	10.50	20.15	0.00	15.60	810.61
Jul 16	29.70	11.10	20.40	0.00	11.60	826.56
Jul 17	23.70	12.80	18.25	0.00	9.60	838.20
Jul 18	25.00	12.20	18.60	0.00	6.40	850.70
Jul 19	27.90	10.80	19.35	0.00	n/a	865.15
Jul 20	22.80	14.40	18.60	1.40	n/a	876.49
Jul 21	27.80	15.40	21.60	0.00	n/a	892.07
Jul 22	29.20	14.60	21.90	0.00	n/a	908.55
Jul 23	30.80	14.40	22.60	0.00	n/a	926.25
Jul 24	30.20	15.40	22.80	0.00	n/a	943.74
Jul 25	31.00	14.50	22.75	0.00	n/a	961.63
Jul 26	33.70	15.60	24.65	0.00	n/a	981.96
Jul 27	33.10	19.10	26.10	5.60	n/a	1002.73
Jul 28	21.60	16.10	18.85	1.60	n/a	1013.57
Jul 29	19.80	15.60	17.70	15.00	n/a	1022.85
Jul 30	22.90	15.70	19.30	6.40	n/a	1034.61
Jul 31	24.40	15.40	19.90	0.00	n/a	1047.49
Aug 1	25.00	11.40	18.20	0.00	12.90	1059.79
Aug 2	29.60	10.90	20.25	0.00	14.40	1075.61
Aug 3	32.10	14.80	23.45	0.00	14.00	1094.45
Aug 4	28.30	19.70	24.00	0.00	12.60	1111.57
Aug 5	27.10	12.50	19.80	0.00	14.50	1125.83
Aug 6	30.70	12.10	21.40	0.00	14.10	1142.84
Aug 7	30.80	14.60	22.70	7.20	8.70	1160.59
Aug 8	22.00	14.40	18.20	1.20	9.00	1171.30
Aug 9	17.20	14.60	15.90	10.60	0.00	1178.24
Aug 10	19.20	8.40	13.80	26.20	5.80	1185.13
Aug 11	21.60	6.70	14.15	0.20	8.70	1193.48
Aug 12	22.90	14.90	18.90	4.00	2.30	1205.03
Aug 13	23.70	14.70	19.20	1.80	4.30	1217.17
Aug 14	24.20	13.50	18.85	0.00	5.70	1229.39
Aug 15	21.90	14.20	18.05	0.00	2.10	1239.96
Aug 16	19.10	15.50	17.30	5.60	1.30	1248.65

2018						
Aug 17	21.50	8.60	15.05	0.00	9.30	1257.43
Aug 18	20.50	13.60	17.05	0.00	0.60	1266.73
Aug 19	23.30	16.40	19.85	0.00	5.90	1279.00
Aug 20	24.60	16.70	20.65	0.00	2.30	1292.38
Aug 21	24.70	17.40	21.05	0.00	8.30	1306.03
Aug 22	20.70	13.90	17.30	0.00	1.00	1315.57
Aug 23	21.40	15.80	18.60	3.60	2.90	1326.17
Aug 24	18.80	11.10	14.95	1.60	7.70	1333.45
Aug 25	17.60	8.30	12.95	0.00	6.30	1339.05
Aug 26	17.90	6.90	12.40	11.00	0.20	1344.50
Aug 27	18.00	13.20	15.60	0.00	1.30	1351.71
Aug 28	19.90	13.90	16.90	0.80	1.60	1360.62
Aug 29	19.20	10.90	15.05	7.00	2.70	1368.17
Aug 30	20.10	9.60	14.85	0.00	4.20	1376.09
Aug 31	20.90	9.60	15.25	0.00	6.90	1384.65
Sep 1	22.80	7.30	15.05	0.00	12.60	1394.11
Sep 2	22.40	6.70	14.55	0.00	12.60	1403.10
Sep 3	22.40	8.20	15.30	0.00	9.60	1412.48
Sep 4	19.70	10.20	14.95	9.40	0.60	1420.24
Sep 5	17.50	13.70	15.60	1.00	0.10	1427.18
Sep 6	21.00	11.90	16.45	0.60	5.20	1436.43
Sep 7	18.20	8.50	13.35	0.00	9.50	1442.55
Sep 8	18.80	5.80	12.30	0.20	1.90	1448.44
Sep 9	21.90	12.60	17.25	0.00	7.20	1458.59
Sep 10	20.10	11.70	15.90	0.00	7.20	1467.07
Sep 11	21.00	15.10	18.05	2.40	4.30	1477.16
Sep 12	14.70	11.90	13.30	1.00	0.20	1481.40
Sep 13	19.60	5.00	12.30	0.00	10.90	1487.71
Sep 14	18.10	7.50	12.80	0.00	3.90	1493.49
Sep 15	20.30	7.70	14.00	0.00	8.10	1501.07
Sep 16	21.80	10.20	16.00	0.00	4.80	1510.50
Sep 17	24.00	13.50	18.75	0.00	10.50	1522.56
Sep 18	20.60	15.10	17.85	0.00	2.60	1532.34
Sep 19	21.30	15.70	18.50	0.00	3.50	1542.83
Sep 20	20.20	16.20	18.20	5.60	0.30	1552.58
Sep 21	16.60	11.30	13.95	0.00	7.50	1558.17
Sep 22	13.20	9.70	11.45	15.60	0.00	1560.64
Sep 23	13.00	9.30	11.15	5.80	3.50	1562.84
Sep 24	15.00	4.20	9.60	0.20	10.90	1565.28
Sep 25	16.80	0.50	8.65	0.00	10.10	1568.16
Sep 26	20.70	3.20	11.95	0.00	11.10	1574.87
Sep 27	21.70	4.00	12.85	0.00	10.90	1582.58
Sep 28	16.80	9.20	13.00	0.00	5.90	1587.77
Sep 29	17.30	3.30	10.30	0.00	8.10	1591.80
Sep 30	15.40	1.50	8.45	0.00	5.10	1593.84

Appendix 5.1: Soil health report

nrm laboratories

SOIL HEALTH

REPORT

Report No. 47411 **Sample No.** 131793 **Sample Ref.** CD B10 A	**Cropping:** *No cropping details given* **Field Area:** 0 Ac	**Farm Details:** [redacted] SOIL MINERAL NITROGEN	**Client:** V957 NRM VITICULTURE SERVICE PROTOCOL DEVELOPMENT COOPERS BRIDGE BRAZIERS LANE BRACKNELL RG42 6NS
Date Received: 11/03/2019	**Date Reported:** 04/04/2019		

Soil Chemical Analysis

	Index	Result	Low	Marginal	Target	Marginal	High
P	0	4.6 mg/l					
K	1	90.3 mg/l					
Mg	1	26.3 mg/l					
Organic Matter (LOI)		3.6%	*Level data not available for this crop*				

			Very Acid	Acid	Neutral	Alkali	Very Alkali
Soil pH		8.4					

Where no future crop code has been given, levels are calculated assuming an arable crop. If general fertiliser and lime recommendations have been requested, these are given on the following sheets. The analytical methods used are as described in DEFRA Reference Book 427. The index values are determined from the DEFRA Fertiliser Recommendations RB209 9th Edition.

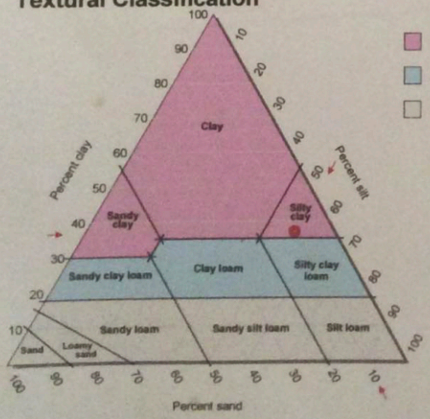
Microbial Activity

	Index	Result	Very Low	Low	Moderate-Low	Moderate	High	Very High
CO_2 Burst	4.7	127 mg/kg						

Potential N Mineralisation (kg/ha/yr) - Based on CO_2 Burst

Very Low (<15) | Low (15-25) | Moderate-Low (25-45) | Moderate (45-75) | **High (75-105)** | Very High (105-123)

Textural Classification



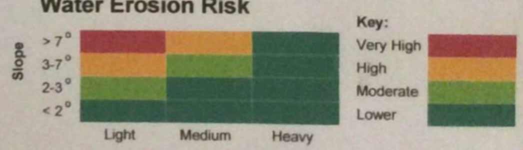
Heavy Soil

Medium Soil

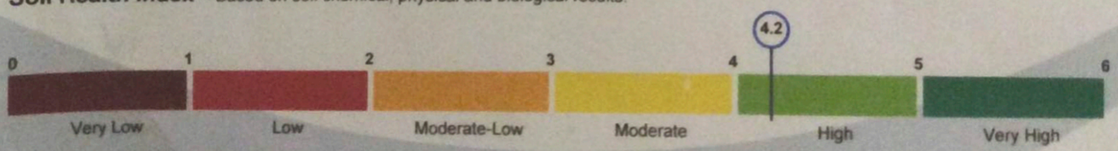
Light Soil

Breakdown:	Sand **10%** Silt **53%** Clay **37%**
Soil Textural Class:	Silty Clay
Major Soil Classification:	Heavy
Slope:	0°

Water Erosion Risk



Soil Health Index - Based on soil chemical, physical and biological results.



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Appendix 5.2: Soil health report continued

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SOIL HEALTH

REPORT (Continued)

Laboratory Reference:
Report No. 47411
Sample No. 131793
Date Reported: 04/04/2019

Soil Health Index Adjustments

Adjustments to the above soil microbial index are made to create the Soil Health Index. The results from the chemical and physical tests summarised on the first page are used to make these adjustments. The table below provides the justification to these adjustments.

Parameter	Adjustment	Justification
pH	Large Negative	Your soil pH is high. Cation trace elements essential for plant health and growth may become locked up in the soil making them unavailable for uptake by the plant. See section 4.1 of the soil health handbook for more information on the influence of high soil pH.
P	Large Negative	The concentration of available phosphorus in your soil is very low. Phosphorus is the second most important nutrient after nitrogen for plant health. A low soil phosphorus level will significantly limit plant production as it plays a significant role in root growth and is involved in most biochemical reactions within the plant. See section 4.2 of the soil health hand book for more information on the importance of phosphorus to plant health.
K	Slight Negative	Potassium availability is low, affecting canopy and root development, and potentially restricting plant uptake of nitrogen. Movement of soluble sugars from leaf to root will be low, affecting root exudate production and plant-microbe interactions. This situation will increase in severity as soil moisture deficit and air temperature increases. See section 4.2 of the soil health handbook for more information on effects of low potassium on plant health.
Mg	Slight Negative	Magnesium availability is low and may be restricting chlorophyll production and plant uptake of nitrogen, which will decrease root exudate production and plant-microbe interactions. See section 4.2 of the soil health handbook for more information on the effects of low soil magnesium concentrations.
Soil Texture	Mode[redacted] Posi[redacted]	The fine micro-aggregate structure of this soil type maintains low exchange rates of air and water, resulting in very slow conversion or loss of soil carbon. Microbial respiration rates will be regulated by [redacted]nd available carbon sources, which may be lower than other mineral soil types, but [redacted]ed over very long periods of time. For more information on how soil texture influences [redacted]ction 3.1 of the soil health handbook.
Soil Organic matter	Slight / Moderate Positive	[redacted]above average and is making a positive contribution to soil structure, nutrient retention, water holding and microbial activity. In addition, this level of organic matter is reducing soil erosion risk. For information on how Organic matter influences the health of your soil see section 3.2 of the soil health handbook.

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Appendix 5.3: Soil Health report continued

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SOIL HEALTH

REPORT (Continued)

Laboratory Reference:
Report No. 47411
Sample No. 131793
Date Reported: 04/04/2019

Field Observations

Parameter	Observation	Comment
Soil Compaction	Absent	Soil compaction can have a major impact on Soil Health and severely limits the performance of your field. The reduced soil pore size will lead to inhibition of root growth and emergence, poor aeration, slow movement of nutrients through the soil and a build-up of toxic gases and root exudates. Compaction can cause a shift in microbial populations from aerobic to anaerobic this will cause a rapid increase in the production of gaseous nitrogen released to the atmosphere denitrification of nitrate. See section 6.6 of the Soil Health Handbook for more information on soil compaction.
Earthworms per cubic foot	0	The presence of earthworms can be a good indication of a health soil system. They thrive in soils rich in organic matter and nutrients and with good aeration all major components of Soil Health. Earthworms in turn improve the health of a soil. They ingest soil particles as they burrow which increases the availability of nutrients both from the chemical and physical breakdown of minerals and organic matter. The burrowing activity also increases the aeration of the soil. For more information on the role of Earthworms in Soil health please see section 6.6 of the handbook.
Nutrient Deficiency	Absent	Nutrient deficiency symptoms in your crop can be the first sign that there is either an imbalance of nutrients in the soil inhibiting uptake or that there is a deficiency of particular nutrients. It is often possible to identify the deficiency from the characteristics of the symptoms however there are some symptoms that could indicate a number of possible deficiencies. If the deficiency issues are not highlighted from the chemical analysis of the major nutrients, additional analysis of trace elements may be required to aid identification of the deficiency/imbalance. There are a number of published descriptions of nutrient deficiencies in crops and these should be referred to when making your assessment. Symptoms of the major nutrient deficiencies (P, K and Mg) are described in section 4 of the handbook.

[redacted]

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Appendix 5.4: Soil Health report continued

ANALYTICAL REPORT

Report Number	47411-19	V957	NRM VITICULTURE SERVICE
Date Received	11-MAR-2019		PROTOCOL DEVELOPMENT
Date Reported	02-APR-2019		COOPERS BRIDGE
Project	SOIL MINERAL NITROGEN		BRAZIERS LANE
Reference	[redacted]		BRACKNELL
Order Number			RG42 6NS

Client [redacted]

Laboratory Reference		MINN131793	MINN131794	MINN131795	MINN131796
Sample Reference		CD B10 A	CD B10 B	CD B31 A	CD B31 B
Determinand	Unit	SOIL	SOIL	SOIL	SOIL
pH water [1:2.5]		8.4	9.1	6.8	8.5
Available Phosphorus (Index)	mg/l	4.6 (0)	<2.5 (0)	8.2 (0)	<2.5 (0)
Available Potassium (Index)	mg/l	90.3 (1)	31.0 (0)	89.8 (1)	114 (1)
Available Magnesium (Index)	mg/l	26.3 (1)	13.2 (0)	121 (3)	471 (6)
Sand 2.00-0.063mm	% w/w	10	5	14	2
Silt 0.063-0.002mm	% w/w	53	60	50	31
Clay <0.002mm	% w/w	37	35	36	67
Nitrate Nitrogen	mg/kg	4.59	6.07	1.46	0.14
Ammonium Nitrogen	mg/kg	1.04	0.26	0.73	0.34
Dry Matter	%	78.0	81.1	74.1	76.0
Conductivity Sat CaSO4	uS/cm	2062	2062	2032	2101
Mehlich III Copper	mg/l	1.4	<1	2.8	1.5
Mehlich III Zinc	mg/l	4.6	<2	<2	<2
Mehlich III Iron	mg/l	50.0	31.4	273	52.5
Mehlich III Manganese	mg/l	29.8	27.6	25.1	19.9
Mehlich III Sulphate	mg/l	33.8	21.5	35.9	119
Organic Matter LOI	% w/w	3.6	0.7	5.4	2.5
Total Nitrogen	% w/w	0.224	0.039	0.235	0.054
Neutralising Value as CaCO3 eq	% w/w	73.3	87.5	1.2	23.3
Neutralising Value as CaO eq	% w/w	41.1	49.1	<1	13.0
Hot Water Soluble Boron	mg/l	1.4	0.3	1.7	1.7
Exchangeable Calcium	meq/100g	9.6	2.7	17.3	18.8
Exchangeable Potassium	meq/100g	0.25	0.06	0.25	0.27
Exchangeable Magnesium	meq/100g	0.35	0.14	1.19	3.86
Exchangeable Sodium	meq/100g	0.02	0.02	0.15	0.53

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ANALYTICAL REPORT

Report Number	47411-19	V957	NRM VITICULTURE SERVICE
Date Received	11-MAR-2019		PROTOCOL DEVELOPMENT
Date Reported	02-APR-2019		COOPERS BRIDGE
Project	SOIL MINERAL NITROGEN		BRAZIERS LANE
Reference	[redacted]		BRACKNELL
Order Number			RG42 6NS

Client [redacted]

Laboratory Reference		MINN131793	MINN131794	MINN131795	MINN131796
Sample Reference		CD B10 A	CD B10 B	CD B31 A	CD B31 B
Determinand	Unit	SOIL	SOIL	SOIL	SOIL
Cation Exchange Capacity	meq/100g	10.4	2.9	22.8	23.4
Mehlich III Phosphorus	mg/l	<2	<2	19.5	<2
Mehlich III Calcium	[redacted]	[redacted]	48195	3389	16465
Mehlich III Potassium	[redacted]	[redacted]	21.3	74.6	80.8
Mehlich III Magnesium	[redacted]	[redacted]	76.0	141	495
Mehlich III Sodium	[redacted]	[redacted]	<20	30.6	102
Active Calcium	[redacted]	[redacted]	30	<1	17
CO2 Soil Respiration	[redacted]	[redacted]		132	15
Colour Index		4.72		4.76	2.26

Notes

Analysis Notes: The sample submitted was small and made it difficult to complete all analysis requested.
The results as reported relate only to the item(s) submitted for testing.
The results are presented on an as received basis unless otherwise stipulated.

Document Control: **This test report shall not be reproduced, except in full, without the written approval of the laboratory.**

Reported by: *Dr S Pitcher*

Natural Resource Management, a trading division of Cawood Scientific Ltd.
Coopers Bridge, Braziers Lane, Bracknell, Berkshire, RG42 6NS
Tel: 01344 886338
Fax: 01344 890972
email: enquiries@nrm.uk.com

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Appendix 6.1: Soil map of pH levels of site

SOYL

Soil Nutrient Level Map

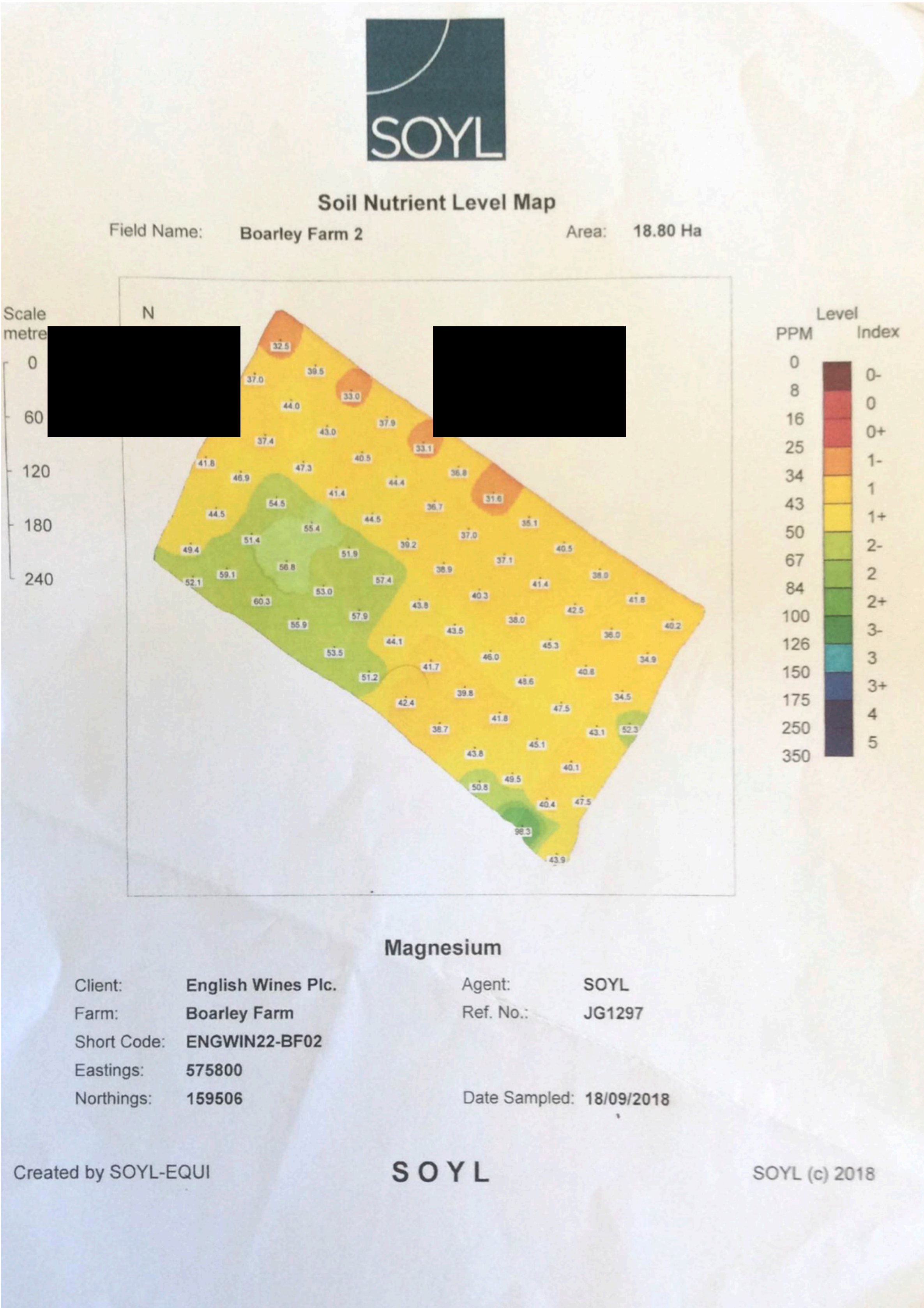
Field Name: **Boarley Farm 2** Area: **18.80 Ha**

pH

Client:	[redacted]	Agent:	**SOYL**
Farm:		Ref. No.:	**JG1297**
Short Code:	**ENGWIN22-BF02**		
Eastings:	**575800**		
Northings:	**159506**	Date Sampled:	**18/09/2018**

Created by SOYL-EQUI **SOYL**

Appendix 6.2: Soil map Magnesium levels of site



VINE CARE UK

QUOTE

Harry Kirby
[redacted]

Quote Date
11 Sep 2019
Account Number

Quote Number
QU-0055
Reference

UK Vine Care Ltd
22 High Park Avenue
Hove
BN3 8PE

07590 845268
Jo@vinecareuk.com
www.vinecareuk.com

Description	Quantity	Unit Price	VAT	Amount GBP
Vines	4,545.00	1.70	No VAT	7,726.50
Hadley Magnum End posts 2.75m	80.00	13.10	20%	1,048.00
Hadley Maxi posts 2.5m	900.00	6.16	20%	5,544.00
Metal Vine supports	4,545.00	0.32	20%	1,454.40
Vine tubes 50cm	4,545.00	0.34	20%	1,545.30
AD Clips (bags of 100)	46.00	3.60	20%	165.60
Gripple GPAK PM3	80.00	3.44	20%	275.20
Gripple 3 Anchor cables	80.00	4.28	20%	342.40
Hangers	160.00	0.31	20%	49.60
Chains 7 links	320.00	0.17	20%	54.40
Gripples medium	160.00	0.83	20%	132.80
Wire 2.0mm	19.00	36.12	20%	686.28
Wire 2.4mm	15.00	36.12	20%	541.80
Preparation of soil including spraying off with herbicide,sub soiling/ploughing and 2 x passes with power harrow	1.00	130.00	20%	130.00
Labour for trellising	1.00	2,700.00	20%	2,700.00
Labour for planting by GPS Machine	4,545.00	0.60	20%	2,727.00
Labour to insert rods and tubes	4,545.00	0.14	20%	636.30
Delivery	1.00	500.00	20%	500.00
			Subtotal	26,259.58
			Total No VAT	0.00
			Total VAT 20%	3,706.62
			Quote Total GBP	29,966.20
			Total Net Payments GBP	0.00
			TOTAL GBP	**29,966.20**

Terms

QUOTE VALID FOR 30 DAYS

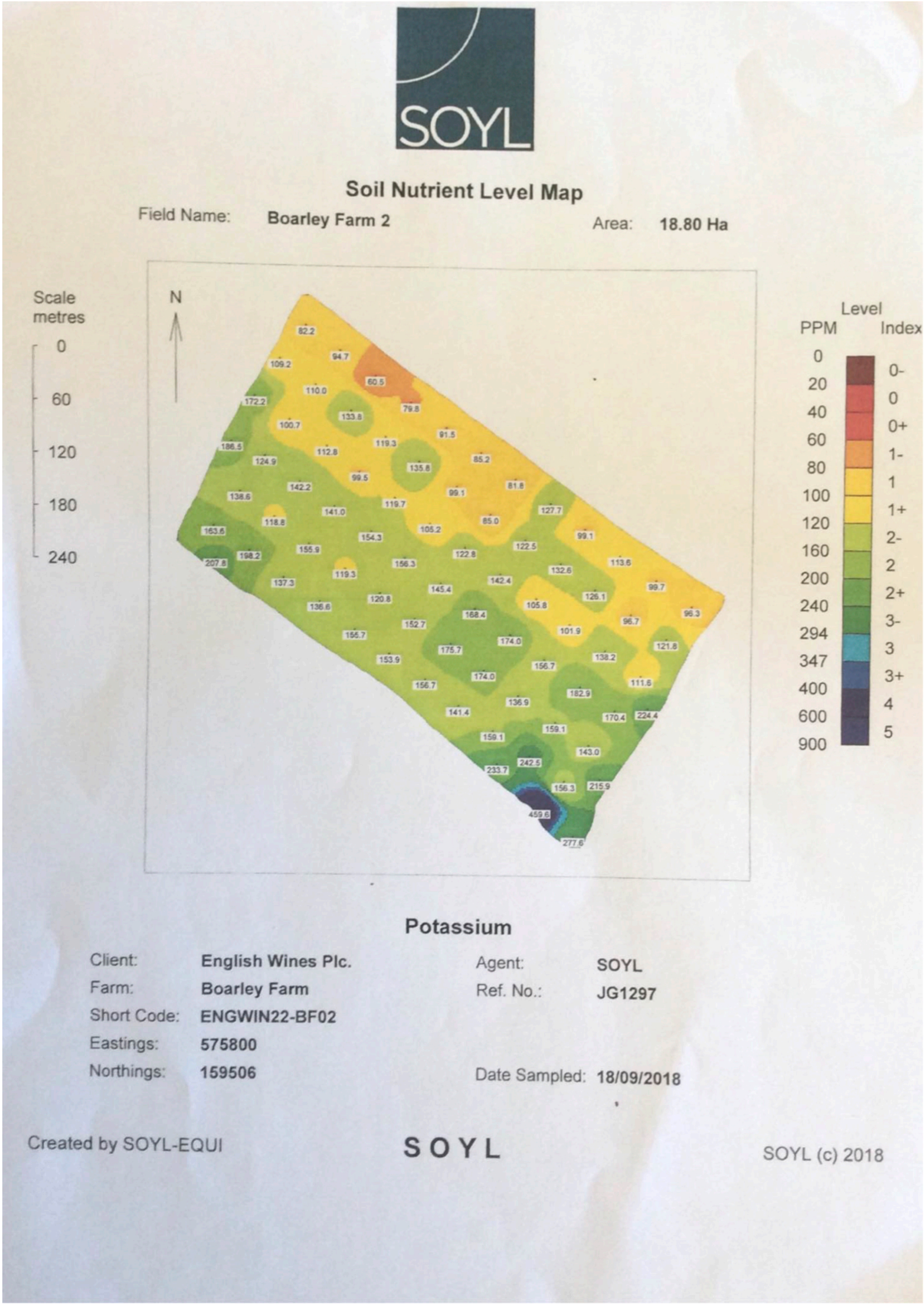
Price based on 1 hectare of vines assuming 13.12 hectares will be planted.

Payment of materials:
50% on acceptance of quote.
50% on delivery.
Quote based on client supplying and paying for diesel for the trellising.

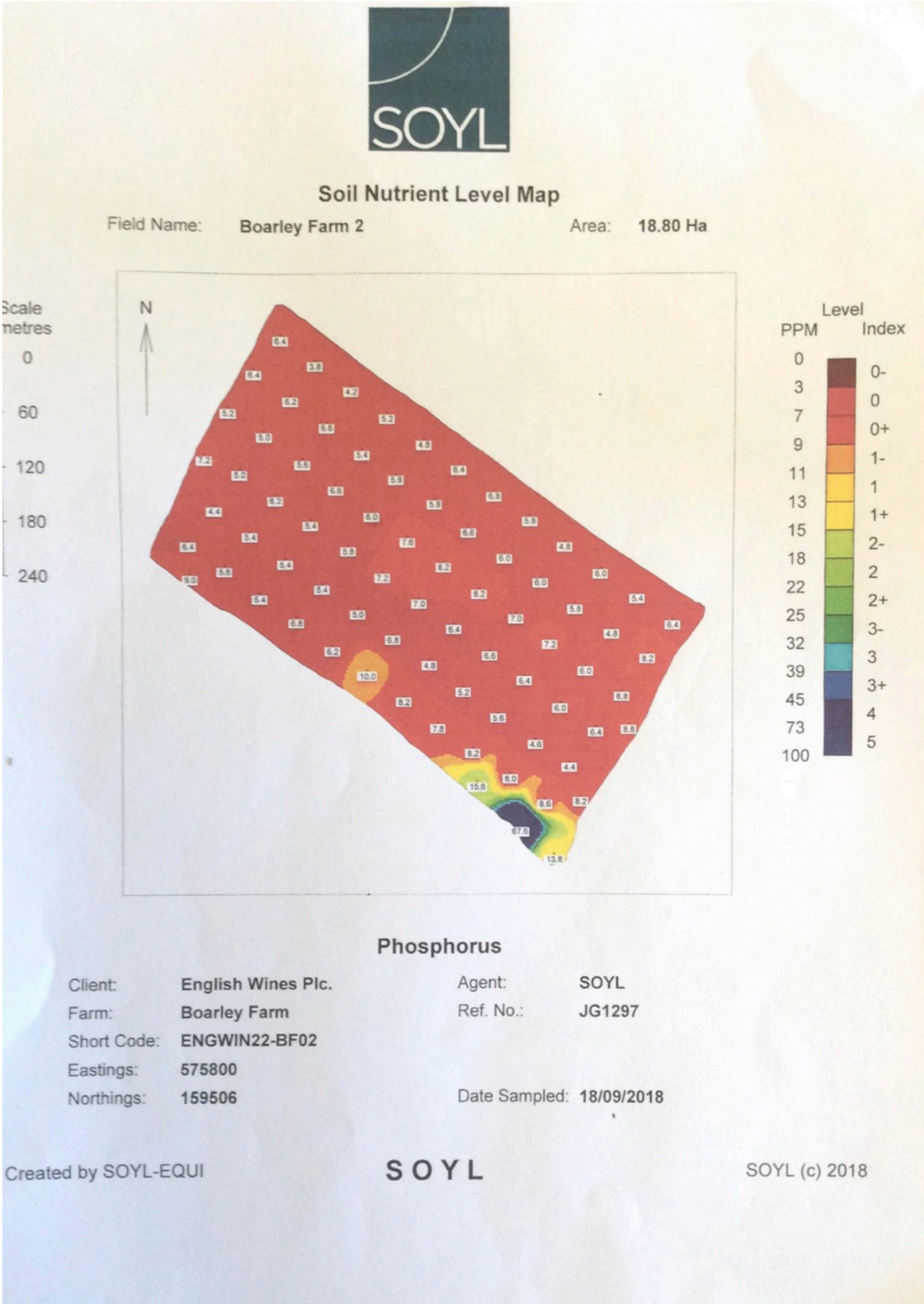
The safekeeping and security of delivered goods are the responsibility of the client.

Materials maybe subject to tariffs after Brexit.

Appendix 6.3: Soil map potassium levels of site



Appendix 6.4: Soil map of phosphorous levels of site



Soil Nutrient Level Map

Field Name: **Boarley Farm 2** Area: **18.80 Ha**

Phosphorus

Client:	**English Wines Plc.**	Agent:	**SOYL**
Farm:	**Boarley Farm**	Ref. No.:	**JG1297**
Short Code:	**ENGWIN22-BF02**		
Eastings:	**575800**		
Northings:	**159506**	Date Sampled:	**18/09/2018**

Created by SOYL-EQUI **SOYL** SOYL (c) 2018

Appendix 7: Invoice for hedgerow acquisition and planting.

Ashridge Trees Limited
Grove Cross Barn, Grove Cross
Castle Cary
Somerset BA7 7NJ
email: support@ashridgetrees.co.uk

Order # 453403
Order Date: 5 Sep 2019
Order Status: Quote

Sold to:	Ship to:
HARRY KIRBY 31 Venture Court Canal Road Gravesend, Kent, DA12 2AT United Kingdom T: 07429300255	HARRY KIRBY 31 Venture Court Canal Road Gravesend, Kent, DA12 2AT United Kingdom T: 07429300255

Payment Method	Shipping Method:
Paysafe EmailPay Credit Card Type: N/A	Custom Shipping Price - Custom Shipping Price (Total Shipping Charges £0.00)

Products	Size	Price	Qty	Tax	Subtotal
Native Conservation Hedge Mix - 50 Pack *60/80 cm* 25 x Hawthorn, Quickthorn-60/80 cm-Bareroot 5 x Blackthorn-60/80 cm-Bareroot 5 x Maple, Field-60/80 cm-Bareroot 5 x Hazel, Common-60/80 cm-Bareroot 5 x Rose, Dog-60/80 cm-Bareroot 5 x Dogwood, Common-60/80 cm-Bareroot	PACKCHM-PK	**£23.51**	**150**	**£528.98**	**£3,526.50**
Spirals, Perforated-60 cm		**£0.15**	7500	**£168.75**	**£1,125.00**
Bamboo Canes-90 cm-Bareroot		**£0.10**	7500	**£112.50**	**£750.00**

Subtotal:	**£5,401.50**
Discount (Manual Discount):	**-£1,350.37**
Tax:	**£810.23**
Grand Total:	**£4,861.36**

Appendix 8: Invoice for Vine planting and trellis installation

Appendix 9: Invoice for Drainage installation

Dear Harry

Thank you for your enquiry regarding drainage I suggest you budget as below:

80mm diam perforated plastic pipe in trench 125mm wide up to 900mm depth, backfilled with 40/20mm shingle or crushed clean hard stone to within 225mm of surface

900 metres @ £ 13.80 per metre
3 no outfall units with rigid plastic outfall pipe & vermin traps @ £80.00 each
Provide as laid plans £360.00
Mobilisation of plant and equipment, welfare etc. Allow £3,610.00 (subject to confirmation of destination).

TOTAL £16,630.00 + VAT

Please note the rates reflect the distance of site from our base and the relatively small amount of work.
If we can be of further assistance please do not hesitate to contact us.

King regards

Lloyd Jones – Contracts Manager
M 07768 885 847 | **T** 01865 736 272 | www.whitehorsecontractors.co.uk
White Horse Contractors Ltd, Stephen's Yard, Enborne, Newbury, Berkshire RG20 0HA

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- LANDSCAPING & CIVIL ENGINEERING
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